

Order FALCONIFORMES

Small to very large diurnal birds of prey. The terms 'diurnal birds of prey' and 'raptor' are used broadly to cover the convergent group of predatory and sometimes scavenging birds, much as 'seabirds' is used for the convergent assemblage of many sorts of marine birds, but not all are diurnal. About 280 species in 70 genera. Three families: Accipitridae, Sagittariidae and Falconidae. Monotypic Sagittariidae (Secretarybird *Sagittarius serpentarius*) extralimital in sub-Saharan Africa (Ethiopian region); other two cosmopolitan, except Antarctica, and represented in HANZAB region by 25 breeding species and one confirmed accidental (24 breeding and one accidental in Aust.; two breeding species and one non-breeding visitor in NZ). Traditionally (e.g. Amadon & Bull 1988; Peters) all diurnal birds of prey have been placed in a single order of four families (three above plus American Vultures Cathartidae). However, general uncertainty about the relationships of the higher taxa and recent studies of DNA-hybridization (Sibley *et al.* 1988; Sibley & Ahlquist 1990; Sibley & Monroe 1990) have led to the removal of the Cathartidae either into a separate order (Cathartiformes) or into a sub-family of the storks Ciconiidae, to which they are most closely related. Other arrangements of the higher taxa have been to put the Accipitridae into one order, with or without the genus *Pandion*, and the Falconidae into another or to put *Pandion* into its own monotypic family (BWP). Here we treat the Accipitridae, including *Pandion*, and the Falconidae as the two families of one Order. The Order may be of Gondwanan origin (Kemp & Crowe 1990).

As a whole, diurnal birds of prey have rather drab plumage in shades of brown, rufous, grey, white and black; patterns on underwings are sometimes important for identifying birds in flight. Field identification often depends more on general characters or jizz (structure, proportions, attitudes of wings in flight, and actions in flight) than on characteristics of plumage. These general characters are hard to describe succinctly and space does not allow us to discuss them exhaustively. Experience in the field with careful instruction from knowledgeable observers is really the only way to acquire skill in identification. However, Porter *et al.* (1986), though dealing specifically with European raptors, give useful information on fundamental differences between the various groups into which Accipitridae and Falconidae are divided.

Silhouettes and attitudes in flight being so important for identification, we have modified the section on Field Identification by adding a section on flight, in which these matters are described. It is as well to define standard terms for the sorts of flight that these birds use. Emarginations of inner and outer webs of primaries, leaves gaps between the feathers and gives a slotted or fingered appearance to wings; obvious and prominent in many Accipitridae, less so in Falconidae. **Gliding**: coasting forward on stiff wings without or between wing-beats; wings flexed according to angle of descent. **Soaring**: maintenance of height above ground or rising and circling up on stiff, fully spread wings and tail. **Hovering**: active flapping into wind to maintain position in relation to the ground. **Poising** (wind-hanging or kiting): facing into wind to maintain position but without flapping. **Stooping**: steep or shallow dive with wings folded close to the body; sometimes at great speed. The term **dihedral** (having two plane faces) describes the V-shaped attitude of the wings when raised above the plane of the body; qualified by **strong**, **medium** and **slight** to denote the degree to which the wings are raised to form a smaller or larger angle between their planes ($>15^\circ$, $5-15^\circ$, $0-5^\circ$ respectively); **modified dihedral** is when the innerwings are raised above the plane of the body but outerwing flat for the most part.

Members of the Order readily recognized by hooked, sharply pointed beaks with waxy membrane or cere at base through which nostrils open, strong powerful feet and sharp curved claws, otherwise found only in owls (Strigiformes), which resemble this order only by convergence. Palate imperfectly desmognathous with palatine processes of maxillae separated for much of their length and so grading into schizognathous type as found in some forms. Basipterygoid processes, absent in all except *Sagittarius*. Generally 14 cervical vertebrae but 15 in Falconidae and *Pandion*, 17 in some vultures (*Gyps*). Often no paired foramina or notches on sternum or else only one of pair. Holorhinal, nares impervious. Two carotids. Caeca, reduced except in *Pandion*. Crop, nearly always well developed; gizzard, poorly developed; fur, feathers, scales, insect chitin and many bones remain in crop and are later regurgitated as a compact pellet. Highly acid stomach for digesting all but chitinous or keratinous parts of prey. Syrinx, tracheo-bronchial. Ambians muscle present. Muscle formula, typically A (BXY in *Sagittarius*). No biceps slip; expensor secundariorum only in *Falco* and a few others. Ten functional primaries, eleventh vestigial or lacking; 11-25 secondaries; diastataxic. Tail with 12-14 rectrices. Feathers with aftershaft, except *Pandion*. Underdown present in varying amount; patches of powder-down in *Elanus*, *Circus*, *Gypaetus* and some others. Oil-gland, well developed, feathered except in *Microhierax*. Eyes, large with high density of cones in retina, giving high resolution; wide field of binocular vision. Hearing, acute. Sense of smell, poor; do not detect prey or carrion by smell, even in Old World vultures (cf. New World vultures [Cathartidae]).

Male nearly always smaller than, or same size as, female; thus different from most other birds; dimorphism greatest in bird-catching *Accipiter* and *Falco*. This reversed sexual dimorphism in size discussed by Reynolds (1972), Amadon (1975), Mendelsohn (1986a,b), Olsen & Olsen (1987), Pleasants & Pleasants (1988, 1989), Montgomerie & Lundberg (1989), J. Olsen (1989, 1990), P. Olsen (1991), Ydenberg & Forbes (1991) and Brown & Amadon¹ and others. Habits normally diurnal but sometimes crepuscular; a few nocturnal (e.g. Letter-winged Kite *Elanus scriptus*). Comfort behaviour includes bathing in water and dust; most adopt a characteristic posture for drying and sunning.

Raptors occur in all land faunas and a variety of climatic zones and habitats. Communities of raptors richest in Tropics and Subtropics and poorest in high latitudes. Patterns of movements vary: resident, migratory or dispersive; juveniles dispersive. In A'asia, small and medium-sized species breeding at high latitudes or altitudes or feeding on seasonally fluctuating prey tend to undertake seasonal movements, which are often towards coast, north (some to New Guinea) or to lower latitudes (Baker-Gabb & Fitzherbert 1989).

In A'asia, local threats to populations include illegal shooting, trapping and poisoning for supposed or real damage to livestock or poultry, or simply because they kill other birds. Egg-collecting, while illegal, is also a threat to some species. Some species have been or are used in falconry, an illegal activity in Aust. Secondary poisoning from pesticides is still a problem. Deforestation and other habitat degradation are the major threats. In consequence, some species are probably declining. Three endemic species are threatened: Square-tailed Kite *Lophoictinia isura*, Red Goshawk *Erythrotriorchis radiatus* and Grey Falcon *Falco hypoleucos* (Brouwer & Garnett 1990).

Further information on behaviour and biology of raptors in Newton (1979), Newton *et al.* (1990) and BWP.

(1) Because this reference and two others are so often used throughout the species accounts for the birds of prey, they are given in the texts without date and not listed in the references; they are Brown & Amadon (1968), Cupper & Cupper (1981) and Hollands (1984). For full details of these references, see the Introduction under Simplified References.

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Family ACCIPITRIDAE vultures, hawks, eagles and Osprey

Superficially diverse assemblage of small hawks to very large eagles and vultures; 200–225 species in more than 60 genera. Eighteen species, including five endemics, breed in Aust. and one is accidental; one species breeds NZ. Remarkably uniform as regards morphology. There is little agreement on subdivisions; up to 15 tribes or sub-families have been proposed by different authors (e.g. Wolters 1976; Amadon & Bull 1988; Kemp & Crowe 1990; Sibley & Monroe 1990; Holdaway 1991), some perhaps consisting of convergently similar species. Here we do not use formal subdivisions and arrange the species essentially in the same order as Peters and Amadon & Bull (1988). However, because the taxonomic affinities of three rather enigmatic endemic Aust. monotypic genera (*Erythrotriorchis*, *Hamirostra* and *Lophoictinia*) are uncertain they are extracted and placed at the end, followed by the somewhat aberrant and specialized *Pandion*, which others have regarded as forming a monotypic family. The following are useful groupings (sometimes considered sub-families):

(1) Honey-buzzards (*Pernis*) and cuckoo-hawks: 14 species in 5–7 genera; one species of *Aviceda* breeds in Aust. Small to medium-sized, without bony brow-ridges; with small weak feet; some crested; densely feathered lores or specialized bills. Plumage often boldly patterned or barred.

(2) Small (white-tailed) kites *Elanus* and others: six species in 3–4 genera; two endemic species of *Elanus* breed in Aust., one of which, Letter-winged Kite *E. scriptus*, fully nocturnal, uniquely so among raptors. Predominantly grey-and-white plumage; characterized by hovering with wings raised in strong dihedral; wings, long and pointed. *Elanus* are specialist predators of rodents. Inside of eggshell, buff, like *Pandion* and Falconidae (cf. green in other Accipitridae).

(3) Large kites (*Milvus*, *Haliastur*) and sea-eagles (*Haliaeetus*): 23 species in ten genera; four species in three genera breed in Aust.: one species of *Milvus*; two species of *Haliastur*, one of which endemic; and one species of *Haliaeetus*. Characterized by easy lazy soaring flight with tilting and twisting of tail, small feet; often of scavenging and piratical habits. The sea-eagles are larger than kites; soar on straighter wings, raised in moderate or strong dihedral, sometimes flat; and generally more predatory and aquatic than kites; tails, graduated or wedge-shaped.

(4) Harriers *Circus* and allies: 17 species in three genera; two species of *Circus* breed in Aust., one of which also breeds NZ. Spotted Harriers *C. assimilis* nest in trees, uniquely so for harriers. Characterized by owl-like facial ruff, large asymmetrical ears, slim body, long narrow wings, long tail and long legs. Fly buoyantly on raised wings, low over land or water; hunt by low-quarterming in open country with wing often in strong dihedral. Only group in which polygyny common (Baker-Gabb 1982). For further discussion of this group, see Nieboer (1973), Baker-Gabb (1982, 1984).

(5) Goshawks and sparrowhawks: 53 species in five genera (see [7], Aust. endemic hawks, below); mostly in *Accipiter* (c. 40 species), which is the largest genus in the Family (see Wattel 1973). Three species of *Accipiter* breed in Aust.; another 19–20 species in New Guinea, Oceania and Wallacea. Typically in wooded lands; hunt from perches or by flying stealthily and dextrously through trees when hunting. Fierce expression caused by heavy brow-ridges; broad wings, rounded at tips; tail, long; legs and toes, long. For further discussion see Wattel (1973), Newton (1986).

(6) Buzzards (*Buteo*), hawks, eagles and allies: 91 species in 21 genera; two species in two genera (*Aquila*, *Hieraaetus*) breed in Aust. (both occurring New Guinea); another, Gurney's Eagle *Aquila gurneyi*, an accidental visitor from New Guinea. The most diverse group of the Family; predatory, soaring raptors with broad wings, bluntly rounded at end. Booted eagles and some other species have feathered tarsi.

(7) Aust. endemic hawks: three species in three monotypic genera in Aust.; perhaps related to other species that are extralimital in the A'asian zoogeographical region (*Henicopernis*, *Megatriorchis*); see Debus & Czechura (1989), Olsen & Olsen (1989), Debus (1991a), Schodde (in press). In general, affinities are quite uncertain (Kemp & Crowe 1990; Holdaway 1991); the resemblance of appearance and habits to typical kites, buzzards or goshawks may be a matter of convergence. Aust. species characterized by much rufous in plumage, especially in juvenile, and strongly patterned underwings.

(8) Osprey: monotypic, cosmopolitan; breeds Aust., not NZ. In several respects differs from rest of Family and stands out in appearance by the contrast of generally brownish upperparts and white head and underparts, distinctive silhouette, flight on long bowed wings, strictly aquatic and maritime habitat and diet predominantly of fish; dives into water to catch prey. Highly specialized and many characters adaptations to habitat and diet: dense plumage to avoid wetting, large feathered oil-gland, no aftershafts on feathers of head and underparts, closeable nostrils, long caecal sacs on intestine (as in other fish-eating birds), powerful feet with rough spicules on soles, long curved claws, reversible outer toe, bony ridges over tendons behind tarsus. Inside of eggshell, ochre, as in *Elanus* kites.

Two other groups, not represented in Aust. or NZ:

(9) Old-World vultures: 14 species in about eight genera. Perhaps the most distinct group in the Family.

(10) Snake-eagles (*Circaetus*) and allies: 14 species in five genera.

Some of the more salient characters shown by most members of the Family are as follows. Size of body varies from small and slender in small hawks to bulky and robust in eagles. Males are generally smaller than females, especially in *Accipiter*, but the reasons for such dimorphism, reversed from what is typical of birds in general, are a matter of debate (see Introduction to Order). Wings, broad, and shape correlated with mode of life and manner of hunting: short and rounded in *Accipiter* for dashing through woodland after prey; long broad and rounded in many other species that do much soaring; hardly ever pointed as in falcons. Similarly, tail varies: from long and square in some bird-catching hawks, kites and harriers, to enhance dexterity in pursuit of prey; to shorter, forked or wedge-shaped in others. Bills always with upper mandible curved down over shorter lower mandible: from slender in honey-buzzards to strong in goshawks and high and powerful in large eagles; not used to kill prey, which is always done by feet and claws, nor in defence and aggression. Long muscular tongue. Nostrils, opening in the cere, may be round, oval, elongated, or slit-like. Loes covered with hair-like feathers except in *Pernis*, which has small stiff scale-like feathers extending to base of bill as protection against attacks of insects. Often well-developed bony ridge over eye. Length and thickness of tarsi, and size and shape of feet and claws, also correlated with type of diet and predatory habits; tarsi and toes tend to be long with sharp claws in bird-hunters; legs long but toes shorter, with curved claws, in reptile-eaters; stout with heavy claws in species that take heavy prey on the ground: usually used for grasping and killing prey and in defence and aggression. Stance, upright or nearly horizontal; some species walk rapidly on flat ground and may even run and chase prey on ground. Right ovary and oviduct well developed, unlike most other birds. Squirt out droppings (cf. Falconidae) (Kemp & Crowe 1990; Newton *et al.* 1990).

Plumages vary greatly; no common features throughout Family but may be similarities within different groups, e.g. harriers, white-tailed kites and many accipiters. Brightest colours are rufous and chestnut; never reds, blues, greens, or yellows. Bare parts and iris often brightly coloured. Some groups tend to have white patches on rump; patterns on underwings, important for identifying soaring birds, often striking, even in otherwise uniformly plumaged species. Most predatory species have white triangular spot on upper nape, concealed unless feathers raised or disarrayed (Hafner & Hafner 1977); significance of this doubtful though it may serve as an appeasement signal. Some with elongation of feathers on head and neck, to form ruff-like or full plume-like crest, often differing in colour from rest of upperparts, often only ornamentation. Little difference in plumage between sexes, though females of some species more strongly patterned than males; considerable individual variation; pale and dark morphs occur, especially among eagles. Bare parts may be brightly coloured (e.g. red) and iris often strikingly yellow, orange, or red (cf. mostly brown in Falconidae). Single annual moult, often starting earlier in females than in males; complete in smaller species; primaries shed outwards, secondaries inwards

starting at two centres (s1 and s5); in larger species, full cycle often not completed within a year and birds in continuous moult, though may be halted during migration or breeding. Young, downy, semi-altricial and nidicolous; first down thick, silky and filamentous, rising from same papillae as later juvenile feathers; soon outgrown by long fluffy, usually white or grey second down, also originating from same papillae and covering whole body. Juveniles of smaller species often reach adult plumage by beginning of second year; those of larger species in third or later years after one or more immature plumages, gradually approaching adult plumage.

Almost world-wide distribution, except Antarctica; only one species in NZ. Found in all sorts of habitat from mountains and open moorlands to lowland forests, from deserts and arid lands to wetlands, both fresh and saline; occur along coasts but never going far to sea into truly marine conditions, where role of predators taken by groups in other Orders (Procellariiformes, Pelecaniformes, Charadriiformes); some species even found in urban environments. Many or most species in n. hemisphere migratory, at least in part; often concentrating in spectacular numbers at narrow sea-crossings or along narrow flyways; most migrating species make much use of soaring in thermals to gain height and gliding from one to another without use of flapping flight, but species of *Circus* feed *en route* and so sustain themselves fly low with flapping. In Aust., movements are poorly known; migration occurs in few species (e.g. *Milvus migrans*, *Circus approximans*, *Lophoictinia isura*); spectacular visible migration on a narrow front has not been noted. Letter-winged Kite *Elanus scriptus* is a species that erupts dramatically at the time of plagues of rodents, but many other species are attracted in large numbers to swarms of locusts, plagues of mice or to fire-fronts. Scavenging kites and vultures are useful in cleaning up man-made mess, perhaps more so in the past than now, and many species play some part in countering plagues of rodents and insects.

Most accipitrids are wholly predatory; some are wholly carrion-eaters; others both. Almost any prey taken: mammals, birds, reptiles, amphibia, fish and various invertebrates such as snails, grasshoppers, locusts and termites. Some species are highly specialized in diet, e.g. snail-eating kites, honey-buzzards. A very few even have a largely vegetable diet (Palm-nut Vulture *Gypohierax angolensis* in Africa). For the most part, hunting and catching methods are by pursuit in flight or by pouncing from a perch; white-tailed kites hover in very characteristic style and harriers quarter low above vegetation or water, both then dropping on prey on the ground. Hunting and feeding is typically diurnal but some (e.g. Bat-Hawk *Machaerhamphus* and *Elanus scriptus*) are crepuscular or nocturnal. Birds are plucked and eaten piecemeal, except very small ones, which may be swallowed whole; mammals are skinned and also torn in pieces but small rodents may be swallowed whole; indigestible matter (fur, feathers, chitin, etc.) regurgitated as pellets.

Displays commonly consist of stereotyped aerial manoeuvres such as undulating dives, slow flapping flight and lowering of legs, and ritualized attack and defence (cf. Falconidae) (Barnard & Simmons 1986; BWP). Outside breeding season, usually solitary except for scavenging species. Probably usually occupy rather large home-range and may maintain exclusive feeding territory within it. On migration in n. hemisphere often notably gregarious or loosely so. Most roost solitarily or in loose pairs in trees or on cliffs and similar high places; some, particularly harriers, roost on the ground, communally. See Newton (1976) for review of dispersion in diurnal birds of prey generally. Also typically solitary breeders, sometimes at traditional sites or in two or three traditional places in a territory, normally making a new nest each year. *Elanus scriptus* is exceptional because it is more or less gregarious throughout the year and breeds colonially or loosely so. Pairs are usually conspicuous at start of breeding season, defending vicinity of nest against conspecifics, other raptors and corvids; defence often done by female, which unlike males seem to stay near nests for entire breeding cycle. Pair-bond, typically monogamous, usually only for the season but in some species may be prolonged and even life-long. Polygyny occurs in some harriers. Activity over nesting territory often conspicuous: soaring or High-circling, singly or in pairs sometimes calling, which may develop into Flight-play in which birds grip each other's feet and spin downwards (Talon-presentation or -grappling and Cartwheeling); also Sky-dances when one of pair plunges and swoops in shallow or deep undulations, often calling and with wings partly closed and still (pothook type) or swinging to and fro (pendulum type) (Brown 1976; Brown & Amadon); Slow-flapping also part of aerial activity. Food-passing by males to females characteristic in many species; mostly during incubation and period of daytime brooding when male brings all food to female; also occurs as part of courtship well before laying. Copulation near or on nest or elsewhere in nesting territory, in some never or rarely on nest; may start well before laying and so probably also part of courtship. Some species bring sprays of green leaves to nest throughout or for part of nesting cycle; function not fully explained but probably for lining of nest, which may have some antiseptic properties, or for camouflage, or may have some social significance. Calls rather unspecialized; mostly loud harsh grating chattering, yelping, yapping, screaming, whistling, whining, or mewing; often resonant and tremulous. Often loaf during day for long periods on favoured perches in characteristic attitudes, e.g. with head drawn into shoulders or jutting forwards; some vultures squat on tarsi on ground or even lie down fully. Spend much time preening; allopreening reported in *Haliaeetus*, *Aquila*, *Lophoictinia*, *Hamirostra* and others. Commonly bathe and drink but some species seem not to drink, even in captivity. Dust- or sand-bathing also reported but incidence in Family as a whole not studied. Shield young in nest from sun or rain by standing and spreading wings; individually may also spread wings partly or fully on favoured perches probably for drying or sunning. Pant, gasp and gular-flutter to dissipate heat. Scratch head direct. Comfort movements (head-scratching, body-shaking) sometimes performed in flight. Some vultures, fish-eagles and *Hamirostra* use stones as tools to break open bones or eggs (Boswall 1977; Aumann 1990; Debus 1991b; Pepper-Edwards & Notley 1991).

Breeding season protracted, especially in large species and in warm latitudes. Nests placed in many situations in trees, on cliffs and even buildings, but on ground in thick cover in most harriers; usually rather or entirely inaccessible. Build own nest of sticks and branches; sometimes all sorts of rubbish in nests of typical kites, vultures and Osprey. Lining of fresh grass or green leaves in some; commonly decorated with sprays of green leaves. Nests of large species often huge by traditional use of same site. Building by both sexes, or entirely by female in *Circus*; material carried in bill or feet. Eggs usually broadly oval, mat, dull white or very faintly bluish and streaked and mottled with brown and red. Clutch-size, small to medium: invariably one in some large species (vultures, snake-eagles); 1–2 in some eagles; 1–3 in typical kites, some fish-eagles, eagles and typical buzzards; 2–6 in white-tailed kites, harriers, accipiters and some typical buzzards. Laying interval: 2 days in small species to 5 days in large. Generally single-brooded because full nesting cycle too long to allow more than one in time suitable for nesting; second broods occur only occasionally in species with a cycle of less than 6 months; yet *Elanus scriptus* apparently breeds almost continuously during plagues of rodents and may lay in second or later nests before young have fledged from first attempt. Clutches may be replaced if lost when fresh but period of replacement short (as early as c. 2 weeks in small species; 29 days in *Haliaeetus*). Nesting cycle of some large tropical eagles lasts longer than 12 months and, if successful, birds breed only every other year. Incubation period 4–8 weeks, depending on size of species, and to some extent on genus (e.g. 35–38 days in *Haliaeetus*, 42–44 days in *Haliaeetus vocifer*, 42–45 days in species of *Aquila* of similar or less weight than *Haliaeetus*, up to 47 days in *Circaetus*). Typically incubation starts with first egg and hatching asynchronous. Incubation mostly or entirely by female but male may cover eggs while she is away. Females have single median brood-patch; males often with none. Eggshells eaten by female or dropped out of nest or carried away. Female alone broods and actively feeds chicks, bill to bill. Usually male brings food for female and young but female may start to hunt again in latter part of nestling period. However, male known to brood young and even feed them in a few species, successfully rearing young when female died. Duties shared equally by sexes only in *Pernis*, snail kites and typical vultures and possibly others. Nestling period long, 4–31 weeks; the larger the species, the longer; difficult to determine accurately because young often clamber outside nest and stay away from it for several days before first flight. Smaller males tend to fledge sooner than larger females. In broods of two or more, youngest chick sometimes dies, being unable to compete for food with older and stronger siblings; may die through starvation, exposure or by being injured or thrown out of nest by siblings, which may eat them if they die in nest. In some eagles, second chick of two never survives even in favourable conditions but dies early in nestling period. In species with broods of two, fighting between siblings often fierce (Cain-and-Abel conflict), the larger persecuting the smaller, even when food plentiful. The adaptive significance of this behaviour much discussed and has led to theories on ecological significance of clutch- and brood-size, mortality in nest and evolutionary processes of its development (Brown *et al.* 1977; Gargett 1978; Simmons 1988; Brown & Amadon). Young of all species depend on parents for some time after fledging but, being difficult to observe and determine exactly, the length of the period is poorly known; certainly varies considerably depending on size and diet, from perhaps 2–3 weeks in small accipiters to a similar number of months in some large eagles and vultures. Age of first breeding 1–2 years in small accipiters and in harriers, 2–3 years in typical kites and buzzards, perhaps 4–9 in large eagles.

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Haliaeetus leucogaster **White-bellied Sea-Eagle**

COLOUR PLATES FACING PAGES 240 & 241

Falco leucogaster Gmelin, 1788, *Syst. Nat. ed.* 13, 1: 257; based on 'White-bellied Eagle' of Latham, 1781, *Gen. Syn. Birds* 1: first p 33 — no locality; Java designated by Hartert, 1902, *Novit. zool.* 9: 427 and New South Wales designated by Mathews 1912, *Novit. Zool.* 18: 248.

The scientific and English names are straight forward translation of one another: white λευκός, belly γαστήρ sea ἄλς eagle ἄετός in its poetic form, αἰήτος.

OTHER ENGLISH NAMES White-breasted Fish-Hawk or Sea-Eagle.

MONOTYPIC

FIELD IDENTIFICATION Length 75–85 cm; wingspan 180–220 cm; weight: male 2.5–3.7 kg, female 2.8–4.2 kg. Large dark-grey and white eagle, similar in size to Wedge-tailed Eagle *Aquila audax*. Unfeathered tarsi; narrow, well-protruding head and neck; short wedge-shaped tail, slightly longer than width of wings at base; wings, long, remarkably broad in innerwing, with long secondaries bulging between shorter inner primaries and secondaries, producing strongly curved trailing-edge, pinched in at body. Juveniles have longer more bulging secondaries forming broader innerwing and distinctly S-curved trailing-edge, more strongly pinched in at body. Tips of remiges pointed in juveniles, forming serrated trailing-edge to innerwing, smooth in adults and immatures. Adult unmistakable; white with black wing-tips on otherwise grey upperwing, and dark-grey saddle, base of tail,

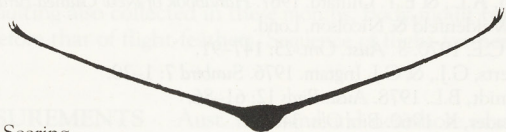


Fig. 1 Soaring



Fig. 2 Gliding

undersurface of remiges and greater coverts. Sexes similar; female larger, distinguished by size when together. No seasonal variation. Juvenile and immatures separable.

Flight Soar with wings raised in strong dihedral (Fig. 1). **Glide** with wings raised in slight to medium modified dihedral (Fig. 2). Head with large bill and long neck protrude almost as far in front of wings as tail does behind. When **soaring**, wings held straight out from body or pushed slightly forward, showing straight leading-edge, six widely separated primary-fingers, and strongly curved trailing-edge pinched in at body; short wedge-shaped tail well spread. When **gliding** slowly, wings as when soaring but primaries closed. In faster glide, carpals pressed forward, primaries closed and outerwings angled backwards, producing angled leading-edge and markedly S-curved trailing-edge; folded tail appears longer, with nearly parallel sides and more strongly wedge-shaped tip. In active flight, powerful rowing wing-beats alternate with short glides.

Description Adult Head, neck and terminal half of uppertail, white; rest of upperparts, dark grey with black wing-tips; base of tail, darker blackish in some. White below, with dark-grey remiges and greater coverts; base of tail, dark grey or blackish, mostly hidden by white under tail-coverts. Bill, blue-grey at base, tipped blackish. Cere and loreal skin, blue-grey. Iris, dark brown. Legs and feet, cream. **Juvenile** Head, creamy, with contrasting dark-brown stripe from behind eye to hind ear-coverts. Upperbody, dark brown, with nape and hindneck densely streaked cream; neat pale scaly appearance to saddle; rump, boldly spotted cream. Upper tail-coverts, dark brown at base; rest, paler whitish, smudged brown. Basal half of tail, white, grading to broad blackish-brown subterminal band, broadest on outer feathers and sometimes forming narrow dark sides to tail. Forewing-coverts, dark brown, with lesser and marginal coverts neatly scaled paler, as saddle; median and hindmost lesser coverts have broader lattice-work pattern of creamy fringes forming prominent narrow pale diagonal band across inner wing-coverts (joins pale grey-brown innermost greater coverts and tertials). Secondaries and greater cov-

erts, blackish brown, with thin pale border to coverts. Primary coverts and fingered portions of primaries, black; rest of primaries, dark grey-brown, forming distinct paler brownish panel in remiges between darker blackish secondaries and black wing-tip. Thin pale trailing-edge to secondaries and inner primaries. Underbody, dark brown; with wear, becomes progressively paler orange-buff, first on vent, then belly, flanks and lower breast, making dark-brown breast and thighs stand out; under tail-coverts, buff-white; undertail, white, with broad dark-brown subterminal band. Underwing: lining mainly orange-buff, in some, separated from dark body by narrow white blaze or larger white area in wing-pit; dark carpal patch and band along leading-edge, petering out about half-way between carpal and body; narrower dark band running in from dark carpal patch about half-way to body; varying dark-brown streaking on median primary coverts; greater primary coverts have white bases and broad dark-brown tips forming dark carpal comma, which continues inwards along greater secondary coverts as prominent dark border to lining. Secondaries, blackish, merging to narrow diffuse white bases and with varying diffuse white streaks; primary-fingers and tips of inner primaries form large black wing-tip; rest of primaries, white, forming large prominent white patch in outerwing, usually with long black streaks (finely speckled black in some). During first year, creamy feather-tips reduced or lost through wear: saddle becomes paler grey-brown and patchy, contrasting slightly with darker upperwings; head and underbody become paler and more uniform creamy buff, heightening contrast with dark-brown band across breast and thighs. Bare parts as adult. **First immature** Upperparts similar to juvenile, differing by: mixture of old paler-brown feathers and new darker pale-fringed feathers gives paler and more variegated appearance to saddle and forewing-coverts; greater and median secondary coverts, paler grey-brown with broader and more diffuse creamy edges giving effect of broader, more uniform and paler diagonal band across inner wing-coverts; rump shows more white without bold pale spots; mainly white tail has narrower, less sharply defined, much paler smudgy grey-brown subterminal band grading to dark brown and becoming broader on tips of outer two feathers but without dark sides of some juveniles, and irregular blackish mottling on basal feathers; head and neck, paler, more uniform creamy buff (though diffusely streaked brown in some), with dark eye-stripe less distinct. Underbody, more uniform, paler buff to off-white, contrasting more with now mottled dark-brown band across breast, and darker orange-buff thighs. Undertail looks white, without tail-band; dark spotting on base hidden by white under tail-coverts. Underwing similar to juvenile but with smaller dark carpal patch not reaching leading-edge, and white area on bases of secondaries, wider, fusing with white patch in outerwing. **Second immature** Similar to first immature, differing by: uppertail appears white, without dark subterminal band, and with varying blackish-brown mottling on basal half (markings often asymmetrical and always more extensive), almost entirely blackish in heavily marked birds, recalling pattern of adult but differing in jagged and blotched (not sharply demarcated) border with white distal half; saddle and forewing-coverts appear variegated (as on first immature); tertials and larger scapulars develop broad creamy tips through bleaching, giving pale blotched appearance to saddle. Head and underbody generally paler, more uniform creamy to off-white (less buff-toned), with more pale streaking on brown band across breast and thighs paler brown to buff-white (though usually slightly darker than belly and flanks). Dark base of undertail mostly hidden by white under tail-coverts. Ground-colour of under wing-lining tends to be paler buff; dark carpal patch, smaller and more interrupted with buff; dark band along leading-

edge inside carpal and second band running inwards off carpal patch, shorter and interrupted with buff. **Subsequent immatures** Appearance gradually becomes like that of adults; upperparts similar to adult but underparts vary.

Similar species Adult and older immatures unmistakable. Juveniles and browner-plumaged immatures may be confused with **Wedge-tailed Eagle** which is darker, more uniform with no white in wing-pit, proportionately longer, narrower, more parallel-edged wings, longer tail, feathered tarsi, less upswept wings in soaring and gliding. Same ages might also be confused with **Black-breasted Buzzard** *Hamirostra melanosternon*, which is distinguished by prominent white bull's-eyes visible on both wing surfaces, by much smaller size, proportionately narrower and more parallel-edged wings, squared or rounded tip of tail and more buoyant rocking flight.

Solitary eagle of coasts, estuaries, rivers, inland lakes and adjacent terrestrial habitats; sometimes over other habitats. Snatch food from surface of water in glide or shallow dive; scavenge, rob other raptors. Perch in sentinel posture for long periods, with tail hanging below wing-cloak. Voice distinctive: loud deep goose-like honking or cackling; begging juveniles give more prolonged yelping or wailing.

HABITAT Maritime habitats, terrestrial wetlands and coastal lands of tropical and temperate Aust. and offshore islands, ranging far inland over large rivers and wetlands. Altitudinal limits unknown; mainly inhabit coastal lowlands, but up to 800 m asl in SA and Tas. (N.J. Mooney), and 1400 m in N. Tablelands, NSW (S.J.S. Debus). Hunt over large open tracts of water, particularly in maritime habitats: inshore waters, islands, coral reefs and cays, bays, inlets, estuaries, mangroves and beaches (Gosper 1981, 1983; Abbott 1982; Smith 1985). Said to prefer coral cays rather than high or continental islands on Great Barrier Reef, Qld (Domm 1977), but rocky islands or those bounded by cliffs used elsewhere (Sedgwick 1978; Abbott 1982). At cays and reefs, take prey from deep water between islands and along reef edges; not in shallow water over reef-flats and lagoons (Smith 1985).

Prefer large open terrestrial wetlands, particularly deep freshwater swamps, lakes, reservoirs and billabongs. Also shallow freshwater swamps, meadows, deep channels, coastal lagoons, saltmarsh, salt pans, sewage ponds and saltfields; ephemeral wetlands inland when filled by floodwaters (Favaloro 1944; Boekel 1976; Vestjens 1977; Cooper 1980; Corrick & Norman 1980; Gosper 1981; Bamford 1988). Rush, reeds, sedge, grasses, waterlilies, shrubs or trees may be present (e.g. *Eleocharis*, *Typha*, *Phragmites*, *Scirpus*, *Nymphaea*, *Muehlenbeckia*, *Melaleuca*, *Casuarina*, *Eucalyptus*), but nature of shoreline or emergent vegetation apparently unimportant, provided open water remains.

Hunt over open terrestrial habitats. On Barrow I., WA, range and hunt over most of island, including *Triodia* grassland (Sedgwick 1978). In Westport, Vic., flushed from burnt grassland and from heath, but not noticed if feeding or loafing (Quinn 1969). Fly over land along coast, in central parts of islands, or round large wetlands; especially grassland, wooded or shrubby coastal dunes, and heath; but also rainforest, forest, woodland, and urban areas (Johnson & Hooper 1973; Roberts & Ingram 1976; Longmore 1978; Harris 1980; Czechura 1984; Smith 1984). Rarely in dense vegetation, but recorded once bathing in creek under closed canopy of rainforest (Bell 1984); noted flying through eucalypt woodland well below canopy (S. Marchant).

Breed on coast and offshore islands, and inland beside large rivers, lakes and swamps; usually in tall trees in or near water but also on cliffs, rock pinnacles and escarpments. Tall open forest and woodland usual; dense forest may be used where sloping

ground or emergent trees allow unobstructed view (Rhodes 1959; Cooper 1974); forest remnants or even tall trees in pasture acceptable (Emison & Bilney 1982); on King I., where most forest has been cleared, nest in trees within *Melaleuca* forest (M. Holdsworth). On predator-free islands, nest low on shrubs, ground, cliffs, islets, rocky shores and platforms (Whitlock 1919).

Search for prey and carrion from perch or on wing. Patrol up to 60 m above water; soar high. Use thermals and updraughts off dunes or cliffs for lift. Take live prey from on or near surface of water, plunging to at least 40 cm depth (Favaloro 1944). Perch and roost in trees, and on tree-stumps, coral boulders on reefs, and beaches (Smith 1985).

Local extinctions and declines in NSW and Vic. attributed to clearing of coastal forest and optimal breeding habitat (Quinn 1969; Bell 1983; Bilney & Emison 1983). In Gippsland Ls, Vic., commonly used nest-tree, *Eucalyptus tereticornis*, extensively cleared for agriculture, settlement and logging; now exists only as remnants and as isolated trees in other plant communities. Eagles can nest in small remnants, even in scattered trees in pasture, but breeding success low. Most nesting territories on private land; more forest reserves, particularly *E. tereticornis*, needed to protect nest-sites (Emison & Bilney 1982). Inland, stabilization of water-levels in major rivers by weirs and locks, construction of reservoirs, and introduction of European Carp have provided stable and abundant food; inland waters may now support greater population of Sea-Eagles and more frequent breeding (Favaloro 1944; Bilney & Emison 1983). Less common in urban habitats than other marine raptors (Osprey, Brahminy Kite) and make little use of artificial structures; but nested on light-tower on E. Lacedpede I., nw. Aust. (Abbott 1982).

DISTRIBUTION AND POPULATION From w. India, E to s. China, and S through se. Asia to New Guinea (including Bismarck Arch.) and Aust. Doubtful NZ records.

Aust. Most of coastline; occasionally well inland along rivers. **Qld** Continuous in N and E, from Gulf Country, throughout C. York Pen. and e. regions (including islands), S to 27°S (Aust. Atlas). Sporadic records from: Darling Downs; SW, Ls Bullawarra and Wyara (Nielsen 1963; Aust. Atlas); and W, S of Boulia, L. Moondarra, Mt Isa region (Horton 1975; Finlayson 1980; Aust. Atlas). **NSW** In E, mainly E of 150°E, and S, from s. coast (Whiter 1987, 1989a,b) across Great Dividing Ra. (e.g. Ls George and Bathurst) (Lamm *et al.* 1963; Lamm 1965) to Riverina (NSW Bird Reps 1977, 1983, 1984) and SW (Hobbs 1961; Guppy 1974; NSW Bird Rep. 1984). Occasionally along Darling R. in W (MacGillivray 1923; Aust. Atlas) and Macquarie Marshes (Hyem 1957; NSW Bird Reps 1977, 1980; Aust. Atlas). **Vic.** Most common from Gabo I. to Wilsons Promontory (Cooper 1974; Reilly 1977, 1978; Bilney & Emison 1983; Vic. Atlas); less frequently W to Port Phillip Bay (Quinn 1969; Vic. Bird Reps 1983, 1984; Vic. Atlas); few records Port Phillip Bay and w. coast (Learmonth 1955; Pescott 1983, 1989; Russell 1986; Vic. Atlas); often in Murray R. valley (Vic. Atlas); sporadic records elsewhere inland (Tarr 1962; Vic. Bird Reps 1982–85; Vic. Atlas). **Tas.** Common and widespread; round entire coast and offshore islands; occasionally inland round lakes and reservoirs. Also King I. and Furneaux Grp (Thomas 1979; Green 1989; Tas. Bird Reps 15, 18). **SA** Absent SE; occurs from Upper Murray to The Coorong, and along coast (including offshore islands) to w. Eyre Pen. (Condon 1969; Eckert 1971; Hornsby 1978; SA Bird Reps 1966–67, 1969–70, 1970–71; Aust. Atlas). Single record from Head of Bight (Aust. Atlas), but lack of records there probably because few observers. **WA** Entire coastline (Serventy & Whittell 1976), including offshore islands, from Eyre Bird Observatory and sw.

Nullarbor (Reilly *et al.* 1975; Anon. 1989) to Kimberley Division, where birds may occur inland to L. Argyle, Windjana Gorge and Geikie Gorge (Aust. Atlas; Storr 1980). Less abundant S of 30°S and W of Arch. of the Recherche (*Corella Seabird Is Ser.*; Aust. Atlas). NT Throughout Top End, S to c. 14°S, to c. 16°S along Victoria R. and in Gulf Country (Crawford 1972; Barnett 1980a; Boekel 1980; Aust. Atlas). Also Melville I., Groote Eylandt (Haselgrove 1975; Aust. Atlas).

Lord Howe I. Single unconfirmed record, 1882 (Hindwood 1940).

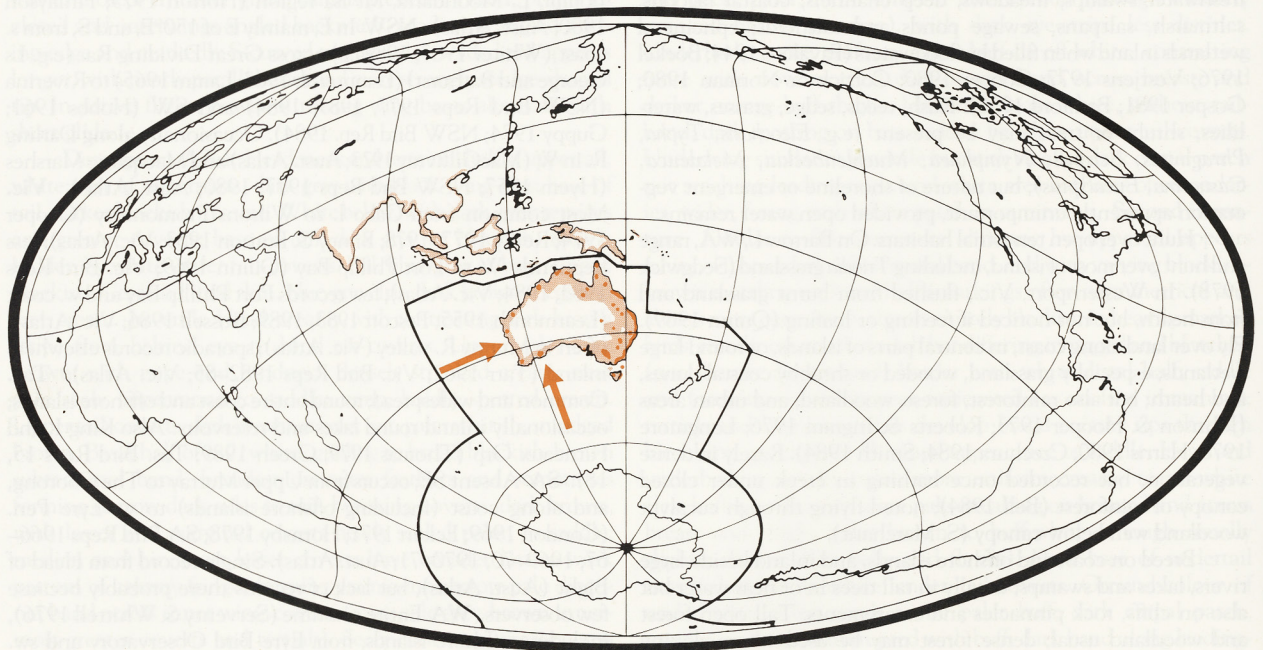
NZ Numerous unconfirmed and unacceptable records, including a specimen of doubtful origin (Oliver).

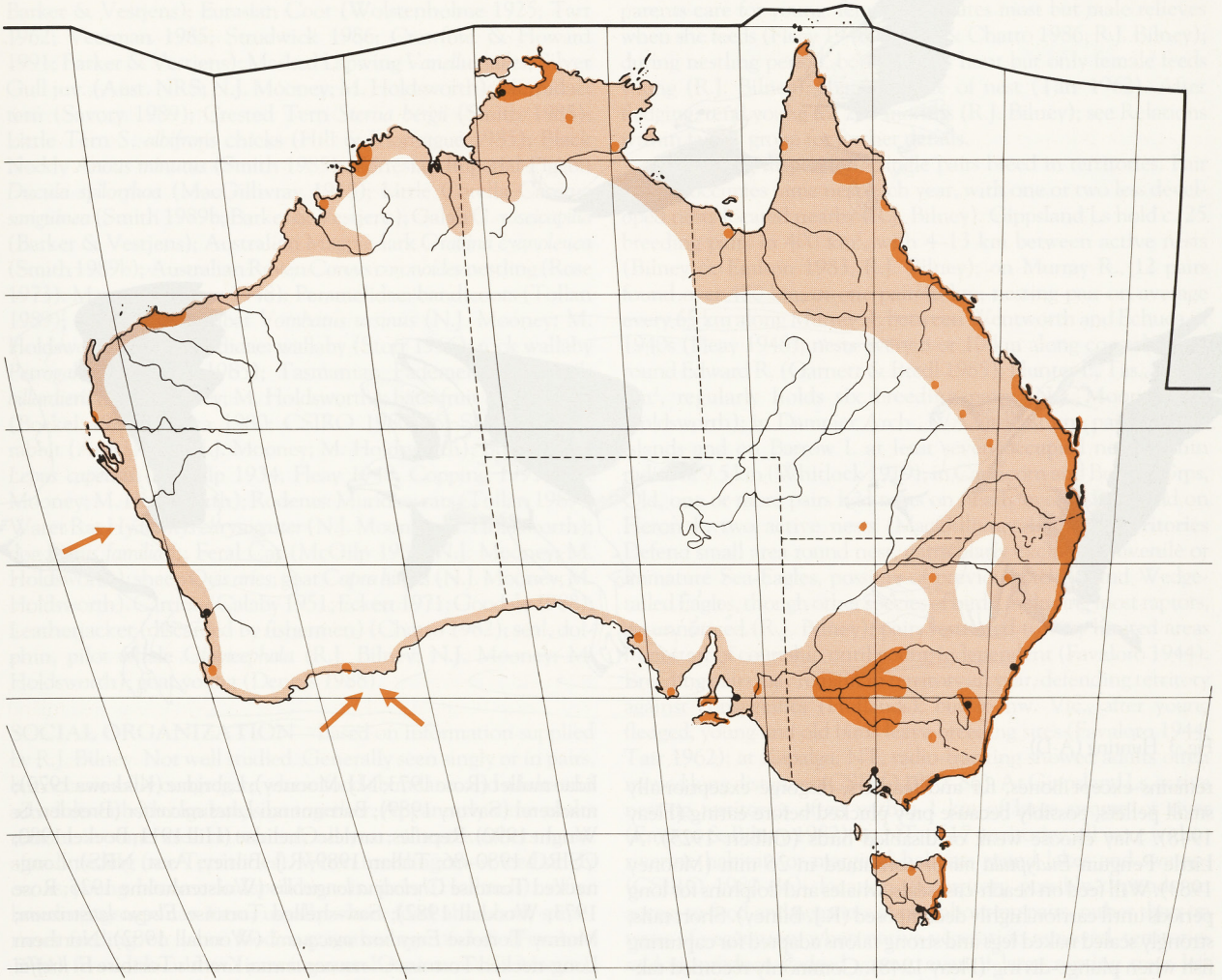
Breeding Patchily along coast from Gulf Country, C. York Pen., Torres Str. and e. coast, S to Gippsland and n. and e. Tas.; Fleurieu, Yorke and Eyre Pens., Arch. of the Recherche; Houtman Abrolhos; sporadic records from sw. and nw. WA and Kimberley Division; throughout Top End. Inland breeding in Murray R. valley and tributaries, and sporadically at other large drainage systems and water impoundments (Hyem 1957; Hobbs 1961; Tarr 1962; Nielsen 1963; Ford 1965; Condon 1969; Bravery 1970; Beruldsen 1972; Serventy & Whittell 1976; Hornsby 1978; Bilney & Emison 1983; Draffan *et al.* 1983; Garnett & Bredl 1985; Aust. Atlas; Aust. NRS).

Inland range may have increased since introduction and proliferation of European Carp (Bilney & Emison 1983). However, previously 'found in good numbers along the Murray River' (Hobbs 1961), but now rarely seen in Sunraysia and adjacent districts of sw. NSW (Hayward & MacFarlane 1971; NSW Bird Rep. 1984; Vic. Bird Rep. 1985). In Gippsland Ls, 20–25 active pairs; 15–20 pairs in Hunter Grp; 10–15 pairs in Furneaux Grp (Mooney 1984); 80–100 breeding pairs in Tas., including islands of Bass Str. (Mooney 1986b). Susceptible to human disturbance; desert nest or young (or deterred from breeding altogether) when disturbed (Kikkawa 1976; Woodall 1982; Bilney & Emison 1983; Mooney 1984, 1986b; Tas. Bird Rep. 1985). Occasionally shot illegally or poisoned (Favaloro 1944; Lamm 1965; Barnett 1980b; Bilney & Emison 1983; du Guesclin *et al.* 1983; Mooney 1986b). Between 1938 and 1970, declared vermin in Roebourne district,

WA, where bounty was paid (Anon. 1943; Serventy & Whittell 1976). Of 12 Tas. birds found dead, eight had been shot and three poisoned (Hunt & Mooney 1983). Recorded drowning in fishing nets (Favaloro 1944). Eat introduced European Carp, rabbits and hares (McGilp 1934; Favaloro 1944; Calaby 1951; Frith 1976), fishermen's offal (Chatto 1982; Favaloro 1944) and 'beach refuse' (Smythies 1981); occasionally congregate in large numbers near rubbish tips (Baker-Gabb 1987). Observed catching disabled fish in polluted waters (Hindwood 1953), but unclear whether organochlorine pesticides are a limiting factor (Bilney & Emison 1983). Clearing of forests on periphery of coastal lakes and inland rivers reduces suitable breeding sites (Bilney & Emison 1983).

MOVEMENTS Resident; established pairs mostly sedentary (Favaloro 1944; Green 1989; Draffan *et al.* 1983; Garnett & Bredl 1985; Hollands; Aust. Atlas) though radio-tracking at Kapalga, NT, suggests territorial adults often move long distances (CSIRO (1980–86); immatures and some adults dispersive (Hobbs 1961; Aust. Atlas; Vic. Atlas); of 18 tagged juveniles at Kapalga, NT, all but one had emigrated or died within 3 years (CSIRO 1980–86). Breeding resident round coastline (Quinn 1969; Crawford 1972; Bilney & Emison 1983; Draffan *et al.* 1983; Garnett & Bredl 1985; Green 1989; Hollands), major rivers (Favaloro 1944; Hobbs 1961; Storr 1980), and some large freshwater lakes (Favaloro 1944; Tarr 1962; Cupper & Cupper; Vic. Atlas). Occasional visitor to inland rivers, lakes and reservoirs beyond usual range (Bravery 1970; Horton 1975; Green 1989; Vic. Atlas). Reported from Atherton, July–early Aug. (Bravery 1970). Reported inland in Kimberley and NT, early summer (Hopkins 1949; Storr 1980); individuals (at least some adult) apparently moving upstream to prey on flying foxes *Pteropus* (Hopkins 1949; Storr 1980). Breeding visitor to some inland lakes; adults and offspring departed from L. Albacutya, Vic., in Dec., following fledging of young; not seen till next July (Tarr 1962). Birds occupying territories on inland waterbodies possibly more dispersive than birds along coast; forced to move as waters disappear (Favaloro 1944; R.J. Bilney); reappear once a lake has filled; at L. Albacutya, one pair returned and bred within 3 years of lake filling for first time in 30





years (Tarr 1962). Drought or lack of food may cause birds to congregate at particular sites; during dry years 1979–83, several congregations of up to ten birds observed at Gippsland Ls; in wetter years since, no gatherings seen (R.J. Bilney). Immatures disperse widely, one bird moving 3000 km from natal territory at Cowell, SA, to Fraser I., Qld (ABBBS); individuals within Gippsland Ls system moving >50 km (R. Chatto). Sometimes congregate at temporary food sources; group of 45, mostly immature birds observed near rubbish tip, Koolan I., nw. WA (Wells & Hooper 1987).

FOOD Carnivorous; opportunistic. Birds, reptiles, fish, mammals, crustaceans and carrion. **Behaviour** Hunting methods include hunting from exposed perch followed by 45° descent and plunge-dive (R.J. Bilney), sometimes almost completely submerging, for surface-swimming fish, sea-snakes and eels (McGilp 1934; Favaloro 1944; Fleay 1948; Green 1959; Hollands; Gould); slow circling followed by dive (Tarr 1962); follow cane-harvesters (Tollan 1989) and dolphins (Schulz & Coyle 1988; Smith 1989a) for flushed prey; feed on ground (Tollan 1989); co-operative hunting between pairs (Crawford & Howard 1991); steal prey singly or in groups from other raptors: Osprey, Whistling Kite *Haliaeetus sphenurus*, Brahminy Kite *Haliaeetus indus*, and conspecifics, even own mate (Debus 1980; Breeden & Wright 1990; R.J. Bilney), Australasian Gannet *Sula serrator* (Mooney

1986a), cormorants *Phalacrocorax*, Pacific Gull *Larus pacificus*, and Silver Gull *L. novaehollandiae* (R.J. Bilney). When stealing prey, harass victim by swooping and attacking with outstretched talons, flipping over on back and attacking from underneath or attempting to grasp prey. Utter high-pitched scream throughout attack till prey dropped or disgorged (Breeden & Wright 1990; R.J. Bilney). If not successful in stealing prey from Gannet, will take Gannet instead (N.J. Mooney). Recorded flying into or at right angles to sun, possibly to prevent shadow on water alerting prey (Favaloro 1944); fly low when searching; when prey sighted, dive with wings partly closed and arched, legs slightly lowered. When near surface of water, talons move forward tightly under chin, body levels, wings are held in stall position and tail depressed. Lash down and back with talons to seize prey, as wings exert downward thrust (see Fig. 3). Prey usually taken in one foot (Favaloro 1944; Calaby 1951; Hollands). When hunting flock of waterbirds (e.g. Eurasian Coot *Fulica atra*), dive steeply on to flock to separate individuals. First attempt often successful with large flocks. With smaller flocks, diving separates individual birds, which then dive. Once Coot dives, Sea-Eagle may glide and fly slightly higher, to dive with wings part-closed once Coot resurfaces. Sea-Eagle will dive repeatedly to drive Coot from flock and exhaust it (R.J. Bilney). Prey eaten on wing (McGilp 1934) or carried to feeding platforms, e.g. top of flattened shrubs (Storr 1966). Food skinned as it is eaten (Mooney 1983). Digest all prey



Fig. 3 Hunting (A-D)

remains except bones, fur and feathers, disgorge exceptionally small pellets, possibly because prey plucked before eating (Fleay 1948). May choose weak or disabled birds (Gilbert 1925). A Little Penguin *Eudyptula minor* consumed in 26 min (Mooney 1983). Will feed on beach-cast seals, whales and dolphins for long periods until carrion highly decomposed (R.J. Bilney). Short tails, strongly scaled naked legs and strong talons adapted for capturing fish when plunge-diving (Fleay 1948). Commonly recorded taking juveniles from colonial nesting species such as cormorants, Darter *Anhinga melanogaster*, Australian White Ibis *Threskiornis molucca*. Feathering only on base of tarsus, permitting legs to plunge into water and handle bloodied prey without staining and matting feathers (R.J. Bilney). Toxic fish (Diodontidae, Tetraodontidae) sometimes taken, so can cope with toxic compounds or avoid toxic parts (Smith 1985; Savory 1989). In n. Qld fish taken mostly pelagic surface-swimmers (Smith 1985).

Adult in n. Qld (food remains at roost, n=79; Smith 1985): Fish: Belonidae: long-toms 31% no.; Fistulariidae 2; Carangidae 2; Labridae 11; Scaridae 4; Tetraodontidae toadfish 2. Reptiles: Hydrophiidae: sea-snakes 4. Birds: Procellariidae 34; Ardeidae 2; Laridae: terns 8. On **Franklin I., SA** (food remains; Eckert 1971): fish 20% est. total. Birds: shearwaters *Puffinus* 60. Mammals: Peramelidae: bandicoot 20 (possibly carrion).

Other records Crustaceans: Decapoda: crayfish (White 1916); crab (Savory 1989); Echinoderms: Asteroidea: starfish (Walker 1987). Fish (CSIRO 1980-86): goldfish *Carassius auratus* (Barker & Vestjens); carp *Cyprinus carpio* (Favaloro 1944; N.J. Mooney; Aust. NRS); *Dicotylichthys* (Savory 1989), *Allomycteris pilatus* (R.J. Bilney); cod (Savory 1989); Anguillidae: eel (1.3 m; Mooney 1983; M. Holdsworth); *Anguilla reinhardtii* (Rose 1973); catfish *Arius graeffei* (R.J. Bilney); pike-eel *Muraenesox* (Wolstenholme 1925); Belonidae: long-toms; pipe fish *Fistularia* (Kikkawa 1970); Redfin *Perca fluviatilis*; Golden Perch *Macquaria ambigua* (Barker & Vestjens); bream *Acanthopagrus* (N.J. Mooney); Mugi-

lide mullet (Rose 1973; N.J. Mooney); Labridae (Kikkawa 1970); mackerel (Savory 1989); Barramundi *Lates calcarifer* (Breedon & Wright 1990). Reptiles: turtles: Chelidae (Hill 1911; Boekel 1980; CSIRO 1980-86; Tollan 1989; R.J. Bilney; Aust. NRS): Long-necked Tortoise *Chelodina longicollis* (Wolstenholme 1925; Rose 1973; Woodall 1982); Saw-shelled Tortoise *Elseya latisternum*; Murray Tortoise *Emydura macquarii* (Woodall 1982); Northern Long-necked Tortoise *C. novaeguineae*; Krefft's Tortoise *E. krefftii* (Swaby & Sellars 1986); *Caretta caretta* (Limpus 1973); lizards (Aust. NRS): Blue-tongue Lizard *Tiliqua scincoides* (Savory 1989); snakes: file-snake *Achrochordus* (CSIRO 1980-86); sea-snakes (Aust. NRS): *Hydrophis* (Cornwall 1908; Hill 1911; Wolstenholme 1925; Mooney 1983; Savory 1989). Birds (CSIRO 1980-86; Aust. NRS): Australasian Grebe *Tachybaptus novaehollandiae* (Barker & Vestjens); Little Penguin (White 1916; Green 1959; Mooney 1983; Aust. NRS); Shy Albatross *Diomedea cauta* chick (Mooney 1984); Procellariidae: petrels (Whitlock 1919; Green 1959); Cape Petrel *Daption capense* (Tarr 1962); shearwaters *Puffinus* (White 1916; Savory 1989; Crawford & Howard 1991): Short-tailed Shearwater *P. tenuirostris* (Quinn 1969; Mooney 1984); Wedge-tailed Shearwater *P. pacificus* (Tarr 1962; Smith 1985; Savory 1989); Australasian Gannet (Cashion 1958; Anon. 1988); Darter; cormorants *Phalacrocorax*; Little Egret *Ardea garzetta* (Barker & Vestjens); Australian White Ibis (Mooney 1988; Tollan 1989); Magpie Goose *Anseranas semipalmata* (CSIRO 1980-86); Cape Barren Goose *Cereopsis novaehollandiae*; Domestic Goose (N.J. Mooney; M. Holdsworth); Maned Duck *Chenonetta jubata* (Aust. NRS); duck *Anas* (Le Souëf 1918; Aust. NRS); Pacific Black Duck *A. superciliosus* (N.J. Mooney; M. Holdsworth); Grey Teal *A. gracilis* (Barker & Vestjens); Brown Falcon *Falco berigora*; Domestic Chicken *Gallus gallus*; Peafowl *Pavo cristatus*; Turkey *Meleagris gallopavo* (N.J. Mooney; M. Holdsworth); Rallidae (Aust. NRS): Tasmanian Native-hen *Gallinula mortierii* (N.J. Mooney; M. Holdsworth); Dusky Moorhen *G. tenebrosa* (Debus 1980;

Barker & Vestjens); Eurasian Coot (Wolstenholme 1925; Tarr 1962; Veerman 1985; Strudwick 1986; Crawford & Howard 1991; Barker & Vestjens); Masked Lapwing *Vanellus miles*; Silver Gull juv. (Aust. NRS; N.J. Mooney; M. Holdsworth); Sternidae: tern (Savory 1989); Crested Tern *Sterna bergii* (Smith 1985); Little Tern *S. albigrons* chicks (Hill & Montague 1985); Black Noddy *Anous minutus* (Smith 1985); Torresian Imperial-Pigeon *Ducula spilorrhoea* (MacGillivray 1918); Little Corella *Cacatua sanguinea* (Smith 1989b; Barker & Vestjens); Galah *C. roseicapilla* (Barker & Vestjens); Australian Magpie-lark *Grallina cyanoleuca* (Smith 1989b); Australian Raven *Corvus coronoides* nestling (Rose 1973). Mammals (Fleay 1948): Peramelidae: bandicoots (Tollan 1989); Common Wombat *Vombatus ursinus* (N.J. Mooney; M. Holdsworth); Macropodidae: wallaby (Storr 1966); rock wallaby *Petrogale* (Veerman 1985); Tasmanian Pademelon *Thylogale billardieri* (N.J. Mooney; M. Holdsworth); bats: fruit bat *Pteropus* (Boekel 1980; Frauca 1980; CSIRO 1980–86; Savory 1989); rabbit (Aust. NRS; N.J. Mooney; M. Holdsworth); Brown Hare *Lepus capensis* (McGilp 1934; Fleay 1948; Copping 1991; N.J. Mooney; M. Holdsworth); Rodents: Muridae: rats (Tollan 1989); Water Rat *Hydromys chrysogaster* (N.J. Mooney; M. Holdsworth); dog *Canis familiaris*; Feral Cat (McGilp 1934; N.J. Mooney; M. Holdsworth); sheep *Ovis aries*; goat *Capra hircus* (N.J. Mooney; M. Holdsworth). Carrion (Calaby 1951; Eckert 1971; Goodale 1988); Leatherjacket (discarded by fishermen) (Chatto 1982); seal, dolphin, pilot whale *Globicephala* (R.J. Bilney; N.J. Mooney; M. Holdsworth); goat young (Dennis 1988).

SOCIAL ORGANIZATION Based on information supplied by R.J. Bilney. Not well studied. Generally seen singly or in pairs, but occasionally congregate where food abundant, and adults and subadults or both regularly soar together. Apparently some adults remain in same area or territory all year, whereas others move after breeding (see Territories). When breeding, most feed singly or, as young become independent, in pairs (Hollands). After breeding, groups can form, usually where food abundant, sometimes feeding on same food, e.g. gatherings of 3–8 (Favaloro 1944); five adults and two immatures at sheep carcass (R. Martin); 14 feeding on fish offal from factory ship (N.J. Mooney); 10–12 roosting near or feeding on carcass (R.J. Bilney). Other records of groups include: seven juveniles near Port Davey, Tas. (Aust. Atlas); 45 at Koolan I., nw. WA, mostly immatures roosting near rubbish tip (Baker-Gabb 1987); ten or more in air at one time, Houtman Abrolhos, WA (Storr 1966); in Oct., in s. Vic., one immature and five adults soaring together; immature and adult feeding at carcass with third Sea-Eagle flying overhead (Hollands). Possibly in poorer seasons, larger congregations occur near coast, e.g. during 1979–83 several groups of up to ten observed in Gippsland Ls, Vic. (R.J. Bilney).

Bonds Lifelong monogamy; if partner dies, quickly replaced (Favaloro 1944; R.J. Bilney); thus some nest-sites continually occupied for many years, e.g. >50, Mallacoota, Vic. (Buckland 1953). No records of subadults attempting to breed, though may be seen in pairs or occupying territories; when male of one pair recorded breeding for 7 years was shot, in June, by early Sept. another male, c. 4 years old, occupied territory but did not breed successfully until 2 years later (R.J. Bilney); a captive female laid first clutch when c. 6 years 10 months old (Fleay 1948). Members of pair said to maintain strong bond throughout year, and call together and copulate out of breeding season (Hollands); in nw. Vic., first sign of courting noted Mar.–Apr. (Favaloro 1944), with Courtship-flights starting Mar. (Tarr 1962); in captivity, nest maintenance and vocalizations started May, continuing to Aug., but one year began late Feb. (Fleay 1948). **Parental care** Both

parents care for young; female incubates most but male relieves when she feeds (Fleay 1948; Bilney & Chatto 1986; R.J. Bilney); during nestling period, both parents hunt but only female feeds young (R.J. Bilney); share defence of nest (Tarr 1962). After fledging, tend young for 2–3 months (R.J. Bilney); see Relations within family group for further details.

Breeding dispersion Single pairs breed in territories. Pair usually occupies same nest each year, with one or two less developed nests located nearby (R.J. Bilney). Gippsland Ls hold c. 25 breeding pairs in 400 km², with 4–13 km between active nests (Bilney & Emison 1983; R.J. Bilney); on Murray R., 12 pairs found over 480 km, or one pair/40 km; nesting pair on average every 65 km along Murray R. between Wentworth and Echuca in 1940s (Fleay 1948); nests every 8 or 10 km along coastal dunes round Edward R. (Garnett & Bredl 1985); Hunter I., Tas., c. 180 km², regularly holds six breeding pairs (N.J. Mooney; M. Holdsworth); in Dampier Arch., WA, at least one pair on most islands and on Barrow I. at least seven occupied nests within radius of 9.5 km (Whitlock 1919); in Capricorn and Bunker Grps, Qld, one or more pairs had nests on nearly every island, and on Heron I., two active nests (MacGillivray 1928). **Territories** Defend small area round nest, particularly excluding juvenile or immature Sea-Eagles, possibly of previous broods, and Wedge-tailed Eagles, though other species of birds, including most raptors, go unnoticed (R.J. Bilney); pairs restricted to very limited areas from start of courtship until young independent (Favaloro 1944). Breeding pairs may remain in territory all year, defending territory against conspecifics (Hollands); but in nw. Vic., after young fledged, young and old birds leave breeding sites (Favaloro 1944; Tarr 1962); at Kapalga, NT, radio-tracking showed adults often moved long distances (CSIRO 1980–86). At Gippsland Ls, active nesting territories often within 1 km of large swamp or river (Emison & Bilney 1982); in NT, of 17 territories, all were within riverine habitats or marginal habitats round lakes and swamps (CSIRO 1980–86); location of territory possibly depends on access to food and nearness of neighbouring pairs, rather than on types of vegetation; when native vegetation removed, territories seldom produce fledged young, even if large nesting trees left intact (Bilney & Emison 1983); for description of types of vegetation in territories, see Emison & Bilney (1982). Pair may occupy inactive territory (Bilney & Emison 1983). Young do not claim territory until several years after leaving parent's territory (Hollands). **Home-range** Up to 100 km² (Mooney 1986b). During breeding season, one female, in distinctive moult, recorded along 14 km of lake shore; observed later that day at eyrie 2 km away (R.J. Bilney).

Roosting Adults regularly roost in same trees near nest and have favoured feeding perches (Hollands). Prefer dead trees or branches, or beached logs and trees (G.F. van Tets), which invariably become stained with faeces, and littered underneath with remains of fish, mammals, birds and reptiles ('butcheries', Storr 1966; 'middens', Smith 1985; R.J. Bilney; G.F. van Tets; P.J. Fullagar). Use nests as feeding station, irrespective of nesting activities (Smith 1985). When not breeding, pair generally roosts at site used by male in breeding season. Apart from roost near nest, have favourite perch along river or lake shore where prey eaten, undertake sorties, or observe human activities or those of colonial nesting species (R.J. Bilney), e.g. favoured perch on casuarinas half-way down cliff and in colony of nesting Short-tailed Shearwaters (Quinn 1969). Perch and preen after feeding (Hollands). Favaloro (1944) flushed eight Sea-Eagles from trees within one swamp during day. Roost just before dark (Yorke 1970). No details of departure but one female arrived at nest with prey shortly after sunrise (Cupper & Cupper).

SOCIAL BEHAVIOUR No major studies and not well known; Fleay (1948) mainly studied captive birds. Interference at nest-site, e.g. banding young or photography, causes adults to change nest following year (Bilney & Emison 1983; R.J. Bilney; R. Chatto); approach early in breeding season may cause desertion (Hollands). **Bathing** Seen standing in water in rocky stream with feathers ruffled as if bathing (Bell 1984).

Aerial activity Spectacular performance of twists and turns, while calling (Quinn 1969); fly round and round, calling (Carter 1903); pair call, chase, wheel, glide and soar, particularly in early morning (Favaloro 1944); circle and call loudly before copulation (Yorke 1970). In PNG, Lindgren (1972) observed following two-phase display and described as Courtship: first **MIRROR-FLIGHT**: pair flying close together, usually separated vertically and horizontally by 2–3 m; copy each other's flight, moving up and down or swerving together; sometimes flight strong and direct, other times slow and leisurely; often one dives, making other sideslip or tip over; interspersed with normal flight. Secondly, **TALON-GRAPPLING**: pair gain height using parallel flight, then lower bird turns upside-down and attempts to grasp other's talons; if talons lock together, pair cartwheel downwards, separating near ground, and resume normal flight; if contact not made, lower bird repeats actions until full display accomplished; birds quite noisy (Lindgren 1972). Hollands also observed Talon-grappling in mid-summer in se. Vic.: male glided behind and just above mate, before rising and gaining height with deep wing-beats above female; he then plunged towards female, swooping up again when just above her; as he came, she flipped over and presented talons, rolling back when he had passed; he climbed again and they repeated performance, both gradually gaining height; finally they locked talons and cartwheeled downwards before breaking and flying away. Chatto (1985) often saw Talon-grappling.

Agonistic behaviour When breeding, pair attack intruding conspecifics; male drops food to defend nest (Hollands). Female appears less aggressive than male; also see Anti-predator behaviour of parents. Attacks most violent when defending territory against Wedge-tailed Eagles; Sea-Eagles normally defeated (R.J. Bilney). Sea-Eagles steal prey from other birds by swooping and attacking with outstretched talons, sometimes attacking from beneath by flipping over on back; attempt to grasp prey from victim; may be accompanied by raucous screaming; victims include: conspecifics, Osprey, Whistling Kite, Brahminy Kite, Australasian Gannet, Brown Booby *Sula leucogaster*, cormorants, Pacific Gull and Silver Gull (Breedon & Wright 1990; R.J. Bilney; M. Holdsworth). Other species of raptor attempt to steal prey from Sea-Eagle, e.g. Whistling Kite, though rarely successful; Black-necked Stork *Ephippiorhynchus asiaticus* observed successfully driving Sea-Eagle from prey (Breedon & Wright 1990). Attacked seal, apparently trying to steal fish: circled above and dived steeply at seal, sometimes pulling out just above it but sometimes striking it with talons; two more Sea-Eagles arrived, juvenile and another adult, and all called and attacked seal for 30 min (Hollands). Call when being mobbed by other species of birds (Hollands).

Sexual behaviour Aspects of Aerial activity described above, such as Mirror-flight and Talon-grappling, probably associated with courtship and maintenance of pair-bond. **Courtship** Begins with birds calling and chasing each other; aerial exhibitions occur particularly in early morning (Favaloro 1944; Tarr 1962). In captivity, near start of nesting activities, birds call a lot, male bringing fresh sprays of eucalyptus to nest and becoming very aggressive; pair fly up and down aviary duetting (Fleay 1948). In wild, paired birds also perform loud duets, usually on favourite perch, and often while side by side; when calling, heads thrown back and bills open wide; often in early morning but at any time of

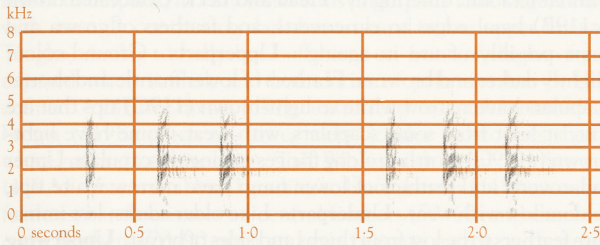
day; in se. Aust., usually from autumn through breeding period, but may occur at any time of year; duetting possibly more common form of display between members of pair than display-flights (Tarr 1962; Hollands). **Greeting** Much calling when approaching nest (Hollands). **Copulation** Before copulation, observed circling and calling loudly; pair flew in and perched on dead limb of prominent eucalypt; male began calling loudly, then flew above female and, with wings outspread, mated; only lasted a few seconds, in late afternoon in Sept. (Yorke 1970). Sexual behaviour can occur when not breeding, e.g. Talon-grappling seen midsummer in se. Vic., and pairs regularly observed calling together and copulating (Hollands).

Relations within family group One captive female incubated with head held well down, whereas male sat with head raised (Fleay 1948). Apparently female broods little after young 3 weeks old, but remains near nest at favourite spots, guarding and waiting for male to bring food (Hollands). Young fed piecemeal, bill to bill (Cupper & Cupper), young pecking food from adult's bill rather than adult passing food to young (Breedon & Wright 1990). When adult circles overhead, young, three-quarters grown, can respond by giving feeble call (Green 1959); when near fledging, young call intermittently when adults away, and call vigorously when adult arrives (Cupper & Cupper). If two in brood, when larger chick fed, a movement by smaller chick may bring response of squawk or peck, or both, by older one, and smaller may lower head; larger one may call if female tries to present food to smaller and female seems to react by continuing to feed larger (Cupper & Cupper); rivalry can lead to death of weaker siblings (Hollands). **Anti-predator responses of young** Crouch flat in nest (Fleay 1948), lying motionless (Whitlock 1919); strike with bill and talons, and edge backwards (Favaloro 1944); bristle up and snatch at intruder with talons (Fleay 1948); menace with bill open and wings extended (Whitlock 1919). **Parental anti-predator strategies** Nest defence not strong (Bilney & Chatto 1986); both parents take part (Fleay 1948; Hollands). Sitting bird may be difficult to flush, return quickly, and refuse to leave nest (Favaloro 1944). When nestlings approached, adults circle above uttering Alarm Calls (Whitlock 1919; Fleay 1948; Green 1959; Cupper & Cupper; Hollands), but may eventually settle nearby (Favaloro 1944; Cupper & Cupper). Male bird in particular seems very aggressive (Fleay 1948; Tarr 1962); male with nestling swooped and called at intruder (Fleay 1948). Exact period fledgelings remain with parents unknown: after fledging, young tended for 2–3 months (Breedon & Wright 1990; R.J. Bilney); hatched July and left parents following Feb. (Favaloro 1944); driven off c. 6 months after hatching but may occasionally stay in territory for more than a few weeks after fledging (Hollands).

VOICE No detailed studies; information from various anecdotal accounts. Main calls, very loud rapidly repeated honks and yelps, often goose-like, described as loud clanging cries, one of 'loudest and farthest carrying bird calls' in Aust. (Fleay 1948); also harsh 'discordant' croaking Alarm Call (Favaloro 1944; Fleay 1948). Call throughout day and daily at some times of year; may call at night, especially moonlit nights and during courtship period (Fleay 1948; Howard & Crawford 1989). Call most during courtship period, decreasing after laying (Fleay 1948). Pairs perform sustained duets at any time of year but particularly during courtship and breeding, and when perched together (Tarr 1962; Hollands). Call of males more highly pitched and repeated more rapidly than that of females; noticeable during duets (Fleay 1948; Tarr 1962). No information on individual differences or geographical variation.

Adult HONK: rapidly repeated, loud and explosive

ank...ank...ank...; deep and nasal, sometimes goose-like (Lindgren 1972; Hollands), sometimes like no other sound; may rise to squeal when excited. Sonagram A shows calls of one bird; sonagram B, duet of a pair. Given in flight, during aerial courtship displays (Mirror-flight, Talon-grappling; Lindgren 1972), especially when mobbed by other birds and when approaching nest. Duets given by pairs when perched side by side or in flight (Pizzey 1980; Hollands). Loud calling from pair in Circling-flight; after landing, lengthy bout of very loud calls, increasing in volume and frequency, before copulation (Yorke 1970). **ALARM CALL:** harsh 'discordant' croaking from nest or in flight; given in response to approach of intruder and while swooping at intruders (Whitlock 1919; Favaloro 1944; Fleay 1948; Green 1959). **Other calls** Reported giving curious cackling cry during aerial display and when mobbed by Swamp Harrier *Circus approximans* (Quinn 1969); reported screaming when attempting to rob other species of food (R.J. Bilney).

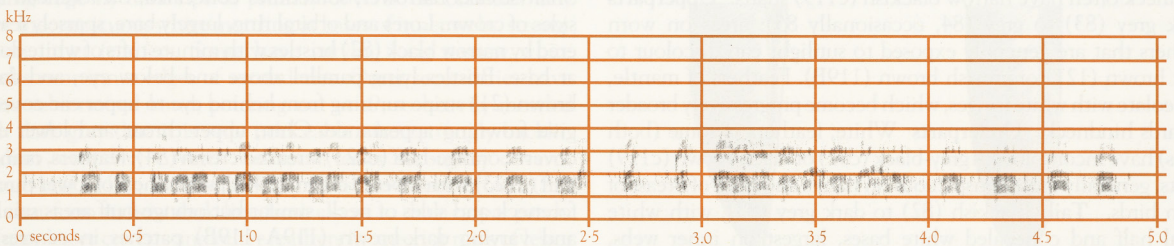


A R. Buckingham; Rotamah I., Vic., Nov. 1982; P35

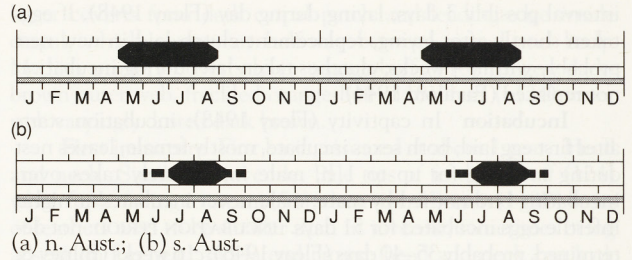
Young Large young reported giving weak croaking calls in absence of parents, intermittently for up to 4 h; vigorous calling when adult approached (Cupper & Cupper); three-quarters-grown young gave feeble calls when parents approached, calling (Green 1959). In one brood of two young, larger chick would squawk, sometimes combined with pecking, as threat to smaller chick to stop it begging for food and to prevent adult offering food to smaller chick (Cupper & Cupper). Fledgelings gave long wailing yelps (S.J.S. Debus).

BREEDING Fairly well known; studies in Gippsland Ls, se. Vic. by Emison & Bilney (1982), and Bilney & Emison (1983); along Murray R. and lakes in nw. Vic. by Favaloro (1944); study of captive pair by Fleay (1948). Breed in simple pairs, solitarily.

Season Broadly defined as June–Dec. in s. Aust., 1–2 months earlier in n. Aust. Nests repaired or constructed 1–4 weeks before laying. Eggs laid: n. Aust., May–Aug.; s. Aust., June–Sept. (Nov.); peak laying, se. Vic., late July–early Aug. Young fledge: n. Aust., Aug.–Oct.; s. Aust., Oct.–Jan. (Feb.); peak fledging, se. Vic., late Nov.–early Dec. (Carter 1903; Cornwall 1908; Favaloro 1944; Bilney & Emison 1983; Aust. NRS). Varies much on Hunter I., possibly in response to availability of food (M. Holdsworth).



B F. van Gessel; Kakadu NP, NT, Aug. 1984; P35



(a) n. Aust.; (b) s. Aust.

Site In tall trees, mangroves, cliffs, rocky outcrops, islets, caves and crevices; on offshore islands: on ground on sandhills and bluffs, or in low bushes such as *Pisonia* palms and snakewood bushes; along coasts and major rivers and round inland lakes; usually next to, sometimes over, water but can be up to 1 km away; in open woodland, farmland, on offshore islands (Cornwall 1908; Whitlock 1919; Bilney & Emison 1983; Aust. NRS). In large fork, horizontal or vertical, of tall tree, living or dead, or in prominent position on cliffs or on ground with commanding view of surrounding area. Height of nests (Aust. NRS): in trees, 16 (3–40; 45), cliffs, 31 (9–70; 14); height of nest-trees: 22 (9–50; 15); depth below top of vegetation: 5.5 (0–15; 23); distance to edge of tree: 3.5 (1–10; 6). In se. Vic., height of nests, 19 (4.0; 12–23; 16); height of nest-trees, 28 (6.5; 22–40; 16). Use traditional sites; or alternate between two or more sites in breeding territory. Choice not influenced by successful broods in previous season, location or distance to water. Second broods (after egg failure) in same nest or new nest built or repaired nearby. Male selects site (Cornwall 1908; Favaloro 1944; Aust. NRS). One nest built on ground in colony of Pied Cormorants *Phalacrocorax varius* (Whitlock 1921).

Nest, Materials Large stick structure with depression for eggs, lined with green leaves, grass, seaweed; become very large with subsequent use; new nest, a scanty construction of green sticks, often with leaves attached (Cornwall 1908; Whitlock 1919, 1921; Favaloro 1944). Built or repaired predominantly by male; eggs laid in nest within 3 weeks of start; fresh lining added during incubation (Favaloro 1944; Fleay 1948). Up to 15 days between completion and laying. New pairs establishing territories known to use old nest of Whistling Kite (D'Ombra 1918; Favaloro 1944). **MEASUREMENTS** (cm): width, 215 (120–270; 6); depth, 135 (50–180; 6); diameter egg-depression width, average 45; depth, average 17.

Eggs Rounded ellipse to oval or elongate oval; coarse-grained, lustreless, sometimes slightly glossy; dull white, sometimes smeared light brown or yellowish brown, probably during incubation (Campbell; North). **MEASUREMENTS:** 73.3 (4; 69.1–82.6; 10) x 55.4 (1; 52.3–56.9)(North).

Clutch-size Usually two; 1–2, rarely three (Carter 1903; Tarr 1962; Aust. NRS). Data on acceptably complete clutches: C/2 x 4, C/1 x 2 (D'Ombra 1918; Favaloro 1944; Aust. NRS).

Laying Information from captive pair suggests laying

interval possibly 3 days; laying during day (Fleay 1948). If eggs taken shortly after laying, replacement clutch laid in new nest probably within 4 weeks; clutches taken later during incubation not replaced (Favaloro 1944).

Incubation In captivity (Fleay 1948): incubation starts after first egg laid; both sexes incubate, mostly female, leaves nest during morning for up to 1 h, male immediately takes over; incubating bird not fed by mate; male never incubates at night; infertile eggs incubated for 51 days. **INCUBATION PERIOD:** not determined, probably 35–40 days (Fleay 1948); c. 6 weeks (Bilney & Emison 1983).

Nestling Semi-altricial, nidifugous, covered in down at hatching. Hatch in white down (Tarr 1962); wing- and tail-feathers emerged, streaky feathers showing on crown, elsewhere still in down at 5 weeks (Hollands).

Growth No information. **Parental care, Role of sexes** Chicks brooded when small (Favaloro 1944); female feeds chicks, male brings prey when chicks small; both do so when young large (Brown & Amadon); chicks fed piecemeal, up to at least 5 weeks old; still in nest at 11 weeks (Cupper & Cupper). No other information. **FLEDGING PERIOD:** 65–70 days (Brown & Amadon).

Fledging to maturity Young fed by adults up to 3 months after fledging; driven out of territory by adults c. 4 months after fledging (Hollands). Depart with adults after fledging (Tarr 1962). Age at first breeding in captivity (Fleay 1948): male collected in Nov. 1935, c. 5 weeks old; female in Dec. 1939, <4 weeks old; male built first nest in May 1942, 6 years 8 months old; relining nest each following year; female laid first clutch in Sept. 1946, 6 years 10 months old.

Success In C/2, one egg sometimes infertile or second young dies before fledging, nests seldom fledging two young (Whitlock 1919; Cupper & Cupper; Aust. NRS). Average productivity of nests in se. Vic. over 4 years, from details in Table 1 in Bilney & Emison (1983): 1.3 young per successful nest, 1.1 per active nest, 0.8 per occupied territory; 34% successful nests fledged two young, 66% fledged one young; nest success lower in farmland than in tall open woodland. At Kapalga, NT, of 13 pairs in 1981, nine produced eggs, only two produced young (CSIRO 1980–86).

PLUMAGES Prepared by D.I. Rogers.

Adult Age attained may vary in wild. Report of captive male and female that attained definitive plumage at 3.5 years (Fleay 1948) widely quoted in secondary literature, but evidence suggests some birds take much longer: captive that moulted from 'brown immature dress' when at least 10 years old (Le Souëf 1921); captive female completing moult to adult plumage when 7 years old (D.J. James); an immature stage, which Fleay's birds apparently never entered, found in museum collections. **Older adults** **Head and neck** White; feathering on lores bristly and can be so short that grey skin below exposed. Feathers of crown and hindneck often have narrow blackish (c119) shafts. **Upperparts** Dark grey (83) to grey (84, occasionally 85); areas on worn feathers that are generally exposed to sunlight can discolour to dark brown (121) or greyish brown (119B). Feathers of mantle, lanceolate with white fringes, which become progressively broader towards hindneck. **Underparts** White; feathers of some (both sexes) have inconspicuous grey-black (c82) or black-brown (c119) shafts, generally most conspicuous on flanks and sides of breast of worn birds. **Tail** Blackish (82) to dark grey (83), with white distal half and concealed white bases, largest on inner webs, especially of outer feathers. From below, dark regions of central feathers largely obscured by white under tail-coverts. **Upperwing**

As upperparts, but p5–p10 have blackish (82) primary-fingers.

Underwing Remiges and all greater coverts, dark grey (83); in strong sunlight may show grey (84) gloss but more often appear blackish by contrast with white body and rest of underwing. Secondaries and greater secondary coverts occasionally have narrow white fringes, broadest on inner feathers. Subhumeral and other under wing-coverts, white; some individuals have dark-grey (83) tips to lesser primary coverts, forming narrow curved dark line parallel to line of greater primary coverts. Remicle, outer web of outermost median primary covert and outer web of outermost primary covert, grey (84). **Younger adults** A captive bird only held this plumage for c. 1 year and was considered immature (Fleay 1948). However, five specimens in this plumage were moulting and had more than one generation of 'younger adult' feathers, suggesting Fleay's (1948) captive may have attained adult plumage quickly. Further, birds can breed in this plumage (e.g. Breeden & Wright 1990) and thus considered adult here. Similar to adult, differing by: **Head and neck** Concealed brown (c119B) basal edges to ear-coverts, and feathers of crown and nape possibly of use in ageing. **Upperparts** Ground-colour slightly darker and browner. Feathers of lower mantle and shorter scapulars have narrow white to light-brown (119C) tips that are lost, at least from some scapulars, with wear. Some have light-brown (c119C) mottling along fringes of longest scapulars. Upper tail-coverts and feathers of lower rump have narrow white tips, seldom lost with wear. **Underparts** Like older adults; last immature feathers to be lost from thighs and sides of breast. **Upperwing** Ground-colour of coverts slightly darker and browner (as upperparts). Marginal and lesser coverts have narrow white to light-brown tips, those on longer lesser coverts readily being lost with wear. Some retain a few immature tertial coverts, grey-brown grading to white at base, with broad cream-buff (92) fringes. **Underwing** Some remiges, particularly inner primaries and outer secondaries, can have inconspicuous long white streaks near inner edge. Some individuals moult into adult body-plumage before moult of primaries begins, thus retaining large white panel of immatures on base of inner primaries. Greater coverts have white fringes, fairly broad from carpal joint to body. Some have dark brownish-grey markings round shaft of smaller lesser primary coverts and lesser secondary coverts near carpal, and traces of brown line on underwing between elbow and carpal. Unclear if this is remnant immature character, or a genuine adult character; certainly present in some birds that have completed primary-moult to adult plumage.

Downy young White.

Juvenile Bird taken into captivity as nestling retained juvenile plumage for c. 12 months (Fleay 1948); wear of remnant juvenile plumage in specimens in post-juvenile moult suggests this is usual. **Head and neck** Crown and hindneck, pale buff (c54), varying, sometimes heavily, streaked dark brown (119A). Feathers, lanceolate with broad varying buff-white (c54) tips and dark-brown (119A) shaft-streaks, which broaden towards bases. Shaft-streaks narrower, sometimes concealed, on forehead and sides of crown. Lores and orbital ring, largely bare, sparsely feathered by narrow black (82) bristles with minute tufts of white down at base. Bristles lying parallel above and below eye, and dark-brown (21) stripe running from behind eye to upper ear-coverts, give frowning appearance. Chin, upper throat and lower ear-coverts, orange-buff (c123) streaked cream (54); feathers, orange-buff (c123) with tapered cream (54) tips. Feathers of lower throat, foreneck and sides of neck, similar but orange-buff areas smaller and varying dark-brown (119A–119B) patches in centres of feathers, largest on foreneck; these areas look dark brown with cream to orange-buff scalloping, often contrasting strongly with

paler head. **Upperparts** Mantle, back and scapulars, dark brown (21–c19) with cream (c54) tips forming neat, pale scalloping when plumage fresh. Feathers of rump, dark brown (21–c19) with white tips, broadest on outer webs of outer feathers, and white mottling on inner webs; appear dark brown, mottled or scalloped white. Upper tail-coverts have large, dark-brown (119A) distal spots, which grade through mottled light-brown (119B–119C) to off-white bases and usually to off-white fringes; spots tend to be larger on inner webs and larger on central feathers; tract appears dark brown with strong white wash intensifying on lateral feathers. **Underparts** Breast, flanks and belly, dark brown (21), with pale-buff (c54) speckling when fresh. Feathers, dark brown (21) with pale-buff (c54) tips and buff (124) to orange-buff (118) bases that are largest at shaft and larger towards vent. Bases concealed when fresh, but can be varying exposed on vent and belly when worn, and on flanks and lower breast when very worn. In moderately worn birds, upper breast looks darker shade of brown than rest of underparts; in very worn birds underparts look largely buff with strongly contrasting dark-brown band across upper breast. Thighs, similar to belly but buff bases on front of thighs often exposed when ruffled, and boundaries of pale tips less boldly defined. Axillaries, cream (c54); central feathers can have mottled brown (119B) patch on lower webs. Under tail-coverts, buff-white grading to white bases. **Tail** White, with broad dark-brown (119A) subterminal band grading to black-brown (119) on outer feathers; band narrower on central feathers (50–60 mm) than on outer feathers (70–90 mm) and can become narrow with wear. White tips can be up to 20 mm when fresh and can be lost with wear. On uppertail, grey-brown or brownish-grey wash inside subterminal band peters out at basal half of central feathers, at basal third of outer feathers. Possibly a few have some blackish mottling at bases of feathers (see Ageing). **Upperwing** Secondaries, black-brown (119) grading to dark-brown (21) outer edges; inner edges and narrow fringes, off-white. Inner three primaries largely black-brown (119), outer seven largely black (89); p1–p6 have mottled light-brown (c119C) patches on outer web, forming small pale patch at bases of primaries in flight. Alula and most greater coverts, black-brown (119) with very narrow light-brown (c119C) tips. White bases to greater primary coverts can be exposed in flight, forming neat white line above primaries. Inner greater secondary coverts, tertials, median secondary coverts and longest one or two rows of lesser coverts, dark brown (21); fringes and inner half of inner web, cream (c54), these areas forming broad pale diagonal bar from centre of wing base towards carpal joint. Other lesser coverts, dark (21) or blackish brown (c19), cream (54) tips forming neat scalloping. **Underwing** Remiges and greater primary coverts mainly dark grey (c83), looking black (82) in dull light, grey (84) in strong light. Primaries and primary coverts have white bases bordered by a little dark-grey speckling. On p1–c. p5, white markings extend almost to tip of feather; on p6 to emargination; on outer primaries they are progressively smaller. White bases form large, nearly square panel, divided near leading-edge by dark tips of primary coverts. Secondaries may have inconspicuous white mottling at bases of inner webs, strongest on inner feathers. Some have varying long narrow white streaks near inner edges of secondaries. Outer secondaries have white subterminal band, petering out at s9, so heavily mottled with dark grey that it is only noticeable when strongly backlit. Median secondary coverts and most lesser secondary coverts, orange-buff (118); longest lesser coverts have dark-brown (21) tips that form narrow dark line from elbow to dark carpal patch. Primary lesser coverts and outer feathers in anterior rows of lesser secondary coverts, dark brown (21) tipped orange-buff (118); tips broad on leading-edge outside carpal, but mostly narrow, making

lesser coverts form dark carpal patch and leading-edge inside carpal, which peters out half-way between carpal and body. Median primary coverts have orange-buff (118) fringes, dark-brown outer web, freckled orange-buff (118); buff (c124) inner web varying dusted dark brown.

First immature First basic; assumed at about 1 year. **Head and neck** Similar to juvenile. Pale tips of feathers, buff (124) when fresh, fading to cream (54) when worn. Brown (119B) bases of feathers tend to be smaller than in juvenile, sometimes being absent on forehead and lateral crown; head and neck can look entirely unstreaked. **Upperparts** Similar to juvenile but pale tips of feathers narrower and lack uniform dark appearance because rather gradual post-juvenile moult causes uneven wear. **Underparts** Usually buff to off-white, contrasting with mottled brown band across breast. Upper breast and foreneck, dark brown (121–119A), streaked light brown (223A) to pale buff (c54) by pale shaft-streaks that often broaden at tips of feather. Lower breast, belly, flanks and axillaries usually have cream-white feathers grading to buffish fringes; appear buff (c124) when fresh, cream (c92) to cream-white when worn. Feathers have black-brown (19) shafts. Some feathers on centre of belly can have light-brown (119C) mottling on outer web. Thighs, light brown (c26–223D), often considerably darker than lower breast, belly and flanks. Some juvenile feathers can be retained at back of thighs. Under tail coverts, off-white. In two birds examined, feathers of belly and flanks similar to juvenile and at a distance appeared dark brown, mottled buff. Even in rare individuals the juvenile-type feathers on flank and belly probably most of underparts paler than band across breast, because post-juvenile moult so protracted that some buff bases of feathers always exposed. **Tail** White, differing from juvenile in less distinct subterminal band and in dark mottling at bases of feathers. Subterminal band mostly uneven light-brown (119C) with indistinct boundaries; paler (119D) and narrower in centre (sometimes barely visible on t1), and grades to dark brown (c21) on t6; on outer feathers dark pigment often restricted to outer webs. Basal halves of feathers varying marked by black-brown (119) patches 5–20 mm in diameter; they cover 5–30% of basal half of tail, tending to be larger on central feathers and often asymmetrical in pattern. **Upperwing** Coverts as upperparts. Remiges as juvenile but usually broader and rounded at tip; this difference most consistent and noticeable on p10 (but see Ageing for notes on two possible exceptions) (Fig. 4). **Underwing** Remiges and greater coverts similar to juvenile; white streaking near inner edges of secondaries generally more distinct; two examined had black speckling on white wing-panel, covering c. 3% of panel on outer two primaries, c. 35% on innermost primaries. Other coverts, similar to juvenile but ground-colour duller, ranging from pale brown (223D) to pale buff (121D). All outer primary coverts, pale brown (223D), some with elongate dark-brown (121) patch in centre of outer web; some also have smaller markings on inner webs. Carpal patch

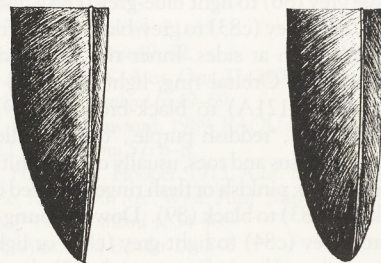


Fig. 4 (A) Juvenile p10

(B) Adult p10

accordingly looks smaller and narrower, not meeting leading-edge of wing; dark tips to longest lesser coverts narrower, so dark line from carpal usually peters out before reaching elbow.

Second (and some subsequent) immatures Attained at beginning of third year; duration spent in this plumage unknown, probably varies (see Adult). Captive female, caged with an amorous and aggressive young adult male, bypassed this plumage stage, moulting directly from first immature to adult plumage (Fleay 1948). Frequency with which this occurs in the wild unknown, perhaps influenced by social and environmental conditions. **Head and neck** Similar to first immature (stage 2); when very worn, can appear entirely dirty white at distance. **Upperparts, Upperwing** Similar to first immature but, when fresh, ground-colour of body and coverts, brown-grey, discolouring to dark brown (c21) with wear; feathers tipped whitish when fresh. Some tertials and longer scapulars can become extremely worn (perhaps retained from juvenile or first immature), their distal quarters fading to pale cream (c92), causing pale-blotched appearance. **Underparts** Similar to first immature, but band across breast may have more pale streaking; belly, flanks and lower breast pale cream (c92) to off-white with black-brown (c19) shafts. Thighs, light brown (223D) to buff-white, usually slightly darker than belly and flanks. **Tail** White; lacks subterminal band although there may be a trace of brown speckling on outer webs of t5. Black-brown (119) mottling on basal half of tail varies considerably, often asymmetrically, but generally more than first immature. Most heavily marked individuals have almost entirely dark basal half to tail, differing from adults only in jagged and blotched border with white distal half; more typically there are large black-brown blotches on basal halves of feathers (generally larger than in first immatures); smaller or absent on inner webs, and generally smaller on outer feathers. **Underwing** Remiges and greater coverts similar to first immature. Coverts similar to first immature; tendency for ground-colour to be paler buffish (c121D). Carpal patch and bars from carpal formed by lesser coverts seem smaller than in first immatures (but little suitable material examined).

ABERRANT PLUMAGES Two juvenile skins entering post-juvenile moult, from Dampier Saltworks and Barrow I., WA, have unusual orange-buff (pale, orange 6) wash on uppertail; in one, undertail similar and colour extends to belly; in other, undertail, orange-rufous (c132) and colour extends on to thighs. In juvenile from Learmonth, WA, tail, pinkish-cream (pale 121D) above, pink-buff (121D) below. Orange-buff tinges are fairly even and are faint to absent on shafts of feathers. They are reminiscent of colours found in the rufous form of Striated Heron *Ardea striata* which occurs on the reddish muds in the same area (Johnstone 1990), which perhaps suggests staining or a dietary effect.

BARE PARTS From photos (Breedon & Wright 1990; Cupper & Cupper; Hollands; unpubl.) and museum labels (AM, ANWC, HLW, MV, QM, SAM, WAM). **Adults, Immatures** Base of bill, cere, and gape, pale grey (86) to light blue-grey (c88); distal third to distal half of bill, dark grey (c83) to grey-black (82), often with brownish-grey (c79) patch at sides. Inner rim of eyelids, grey-black (82) to black (89). Orbital ring, light grey (85) to grey (c84). Iris, dark brown (121A) to black-brown (c119); 'light hazel', 'grey-brown', 'grey', 'reddish purple', 'orange-yellow' and 'amber' also reported. Tarsus and toes, usually cream-white, occasionally buff-yellow (c53); pinkish or flesh tinge recorded on a few labels; claws, dark grey (83) to black (89). **Downy young** Base of bill, cere, and lores, grey (c84) to light grey (c85) or light blue-grey (88); rim of nostrils and base of tomtia, pink (c7); distal half of bill, black (89). When small: Orbital ring, grey (84); iris, black-

brown (119). Tarsus and toes, pale pink (pale 108D); claws, black (89). Juvenile colours attained before fledging. **Juvenile** Similar to adults, but at fledging: cere and base of bill can be grey (c84); orbital ring, green-blue (64) to dark brownish grey (c83); iris can have varying light-brown (119C) outer ring; tarsus and toes can have faint pink tinge.

MOULTS Based mostly on skins (AM, ANWC, HLW, MV, QM, SAM, WAM); also photos.

Adults Records available from 31 adults, 22 with date (collected all months except Dec., Jan.). Moult complex, protracted (seldom completed in a year) and not well understood; remiges and rectrices probably replaced in a staffelmauser. All but two adults examined were in primary-moult; they only had one active moult-wave, moving outwards, with 1–2 growing primaries. Moult-waves are often stopped in at least 45% of individuals, moult resuming at point of interruption; moult of one or two feathers (often outer primaries) occasionally skipped. No direct information on relation between moult and breeding. In tropical Aust., where nesting generally occurs in dry season, all seven collected between Apr. and Nov. were moulting, suggesting much overlap between moult and breeding. **Post-juvenile** Records available from 23 in juvenile plumage or post-juvenile moult, including 18 with date. Generally complete, primaries outwards; moult of body and tail begin at about same time as primaries. Moult begins in second spring, when about 1 year old. In two skins examined, moult-waves had been interrupted. **Subsequent moults of immatures** Records for 27, only 12 with date. Sequences similar to adult, but four examined had two moult-centres in primaries; active moult recorded in all months from May to Dec. (no specimens available from other times of year). In five skins collected when moulting from second immature to adult, moult of body-feathers, remiges and rectrices had begun at about same time. However, four photographs (NPIAW; unpubl.) show birds in adult plumage, but with large white panel in primaries, and small white smudges on inner edges of some secondaries; three also had one or two primaries typical of adults. Apparently, moult of body to adult plumage begins well before moult of remiges in some individuals; possibly a character of birds attaining maturity early and bypassing second immature plumage.

MEASUREMENTS (1) Aust. and PNG, adults and second or subsequent immatures, skins (AM, ANWC, HLW, MV, QM, SAM, WAM). 'Males' with wings of 582 and 586 mm, and 'female' with wing of 548 excluded as they may have been wrongly sexed. (2) Aust. and PNG, juveniles and first immatures in which longest primaries had been retained from juvenile plumage, skins (AM, ANWC, HLW, MV, QM, SAM and WAM). All Aust. localities combined; no known geographical variation; ranges for all measurements in se. Aust., NT and PNG, similar. Apparent similarity in size between sexes in juveniles probably misleading, caused by incorrectly sexed specimens, but distributions for measurements of juveniles seem less clearly double-humped than for adults.

	MALES	FEMALES	
WING	(1) 552 (12.6; 527–572; 14) (2) 535, 571, 592	599 (17.7; 581–633; 16) 591 (13.8; 567–613; 9)	**
8TH P	(1) 384 (13.3; 362–398; 8) (2) 426	429 (13.8; 413–452; 13) 433 (13.9; 406–448; 6)	**
TAIL	(1) 241 (13.8; 225–278; 13) (2) 261, 290, 311	276 (10.0; 263–298; 14) 278 (41.5; 203–322; 9)	**
BILL	(1) 51.6 (1.44; 48.6–53.7; 16)	56.1 (2.97; 48.6–60.9; 16)	**

	(2)	50.1 (2.25; 46.3–52.0; 4)	53.7 (2.59; 47.2–56.6; 10) *
BILL C	(1)	40.3 (1.42; 38.0–42.9; 16)	44.5 (2.00; 39.3–47.3; 16) **
	(2)	39.2 (1.95; 36.6–41.1; 4)	42.2 (2.05; 38.4–45.0; 10) **
TARSUS	(1)	99.6 (5.02; 91.7–109; 8)	104 (9.23; 85.0–116.5; 10) **
	(2)	101, 104	100 (4.64; 94.5–107; 4)
TOE	(1)	63.5 (4.34; 57.0–68.7; 4)	73.2 (6.17; 67.9–86.4; 6) **
	(2)	62.8	65.9 (3.18; 61.2–69.7; 4)

WEIGHTS Aust. and PNG, data from museum labels (AM, ANWC, QM, SAM, WAM) and ABBBS; banded birds sexed on basis of wing measurements: (1) adults and immatures, excludes females of c. 4 and 5.7 kg; includes 'thin' male of 2120; (2) juveniles. Unknown if seasonal or geographical variation occurs.

	MALES	FEMALES
(1)	2400 (220; 2120–2900; 10)	3330 (290; 3000–3900; 12) **
(2)	2410 (110; 2210–2500; 6)	3070 (180; 2900–3400; 6) **

STRUCTURE Wing, long and broad. Eleven primaries; p11 minute, p8 longest; p10 105–123 longer, p9 18–32, p7 0–12, p6 12–23, p5 56–73, p4 110–138, p3 147–170, p2 164–226, p1 186–255. Emarginations on outer webs of p5–p9 (p10 narrow) and inner webs of p6–p10. Fourteen long secondaries and at least three tertials. Five humerals, about as long as median upper wing-coverts. Tail, short and wedge-shaped; 12 feathers. Bill, stout, slightly shorter than head; upper mandible longer than lower, and strongly hooked. Cere, bare and smooth; nostril elliptical. Tarsus, moderately short and stout; basal third feathered in front; rest scutellate in front, reticulate behind. Toes, strong; small overlapping scales on soles cause rough, even spiny texture; outer toe, c. 71% of middle, inner c. 59%, hind c. 63%. Claws, long, curved and strong; middle claw, c. 30 mm in males, c. 34 mm in females; other claws about the same length.

AGEING Juveniles and some first immatures can be told from older immatures on basis of shape of remiges. Remiges of juvenile narrower and more pointed at tip than in older birds; difference most striking on p10, inner edge of which is almost straight in juvenile plumage but forms strongly convex lobe in older birds (see Fig. 4, Plumages). Rather pointed tips to secondaries of juveniles make trailing-edge look serrated in flight; more rounded tips of older birds form smoother trailing-edge. Possible to assign p10 to 'juvenile' or older category in all skins examined (i.e. no intermediates found). Two first immatures examined in primary-moult had juvenile-shaped p10, but old rectrices of same age had strong subterminal bands and blackish mottling that covered at least 15% of basal half of tail; not clear if these birds indicate that some first immatures can also have pointed remiges, or whether they show that a few juveniles have blackish mottling at bases of feathers.

GEOGRAPHICAL VARIATION None known.

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White-bellied Sea-Eagle *Haliaeetus leucogaster* (page 81)

1, 2 Adults; 3, 4 Juveniles, fresh plumage; 5, 6 First immatures; 7 Second immature; 8, 9 Young adults with varying amounts of retained immature plumage

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Volume 2, Plate 20

White-bellied Sea-Eagle *Haliaeetus leucogaster* (page 81)
1 Adult; 2 Juvenile; 3 First immature; 4 Second immature

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